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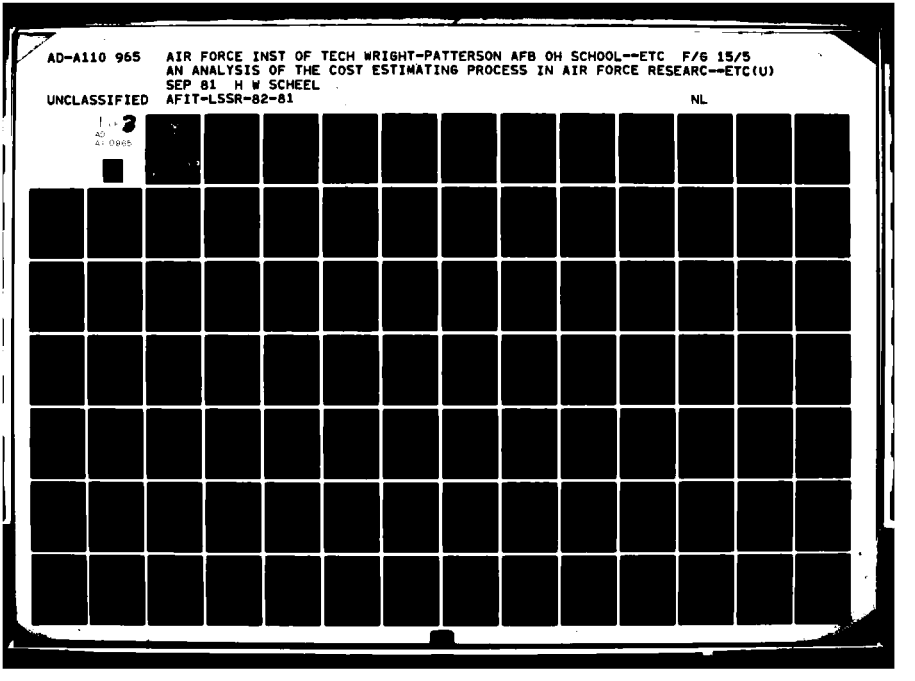

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Wright-Patterson Air Force Base, Ohio

AN ANALYSIS OF THE COST ESTIMATING PROCESS IN AIR FORCE RESEARCH AND DEVELOPMENT LABORATORIES

Hellmut W. F. Scheel, Captain, USAF

LSSR 82-81

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Within Air Force laboratories estimating costs for new projects can be a difficult task for the project manager. This is due to the uncertain nature of the exploratory development projects, which predominate in Air Force laboratories, and the lack of standardized guidelines or procedures to assist in the estimating. The objectives of this thesis were to: (1) Identify the techniques which are commonly used in estimating costs for exploratory development projects (2) Identify factors which contribute to the variance between the project manager's cost estimate and the offeror's proposed costs and (3) Identify weaknesses or limitations in the current cost estimating procedures and develop recommendations for improvement. The results indicate laboratory project managers rely almost exclusively on historical data from past projects or recent cost proposals and/or their own experience to estimate new project costs. Four major factors were identified as contributing to the variance between estimates: (1) Project managers underestimate manpower (2) Project managers underestimate overhead (3) Project managers are constrained by initial estimates or the availability of funds and (4) potential offerors misinterpret the Statement of Work. Two of the major recommendations for improvement were: (1) to establish a computerized data base of past projects and (2) to decrease the acquisition lead time.

LSSR 82-81

AN ANALYSIS OF THE COST ESTIMATING PROCESS IN AIR FORCE RESEARCH AND DEVELOPMENT LABORATORIES

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

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In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Systems Management

By

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CHAPTER 1

INTRODUCTION

Background

Estimating costs for research and development (R&D) programs is a difficult task for Department of Defense (DoD) project managers as well as for their civilian counterparts. One of the primary factors for the difficulty lies in the risk and uncertainty normally associated with R&D programs (20:6). In the manufacture or production of an item with relatively few parts, well defined specifications, and a relatively short production time, the labor and material costs can generally be calculated quite accurately and with a low degree of risk and uncertainty (13:32).

On the other hand, in cost estimating for the research and development of a new weapons system, such as an advanced fighter aircraft where only performance specifications are defined, where thousands of parts and components are involved, and the development effort extends over several years, the risks and uncertainties can significantly increase. Other factors which can contribute to the uncertainty of the R&D cost estimate are: inflation, requirement changes, schedule delays, and policy changes (22:p 7.35). Due to these uncertainties the actual cost of the project can differ substantially from the original estimate. Because future funding requirements for R&D programs are

largely determined by the initial or baseline cost estimates, it is critically important for project managers to minimize controllable error in cost estimating (21:1).

Since the early 1960's a family of management information and reporting systems used by DoD managers during the acquisition of major weapon systems has steadily evolved (18:2). As a result, historical cost data are available for estimating costs for future programs and numerous cost models have been developed (14:166-200). There are two classes of commonly used estimating techniques that are appropriate for R&D programs. These are (1) costing by analogy, in which the costs of similar systems are used for the estimate; and (2) cost estimating relationships (CERs) which are equations relating cost to system performance characteristics (16:145; 23:pp 11-1 to 11-7). These techniques do not guarantee accuracy because of uncontrollable factors such as inflation or a sudden price increase of foreign procured raw materials (15:70; 24:24-27). The models do, however, assist the project manager in estimating costs when many input variables are involved. Unfortunately, the cost estimating techniques and models apply primarily to the acquisition of major weapon systems and their subcomponents.

Within Air Force laboratories estimating costs for new projects becomes less precise and systematic. These laboratories are engaged primarily in exploratory development programs, which by their very nature, are more uncertain

with regards to achieving their objectives than major weapons systems that have precisely defined and quantified objectives (2:1). (See Appendix A for the definition of an exploratory development program.)

An example of an objective for an exploratory development program would be: "To develop a solid rocket propellant for the Space Shuttle boosters that will produce 10% more thrust than the current propellant." Of course, additional performance specifications, such as the specific impulse to achieve the desired thrust level and the mechanical properties required of the propellant, would be available to narrow the scope of the effort. However, the laboratory project manager is faced with many questions when estimating costs for this project. How does the manager determine the number of manhours required to develop this new propellant that is pushing the state-of-the-art? How many variations and combinations of the propellant ingredients are required before the desired level of performance is achieved? If the performance level is achieved, will the mechanical properties requirements be met? If not, how many additional combinations of ingredients are needed before both performance and mechanical properties requirements are achieved? In short, the level of effort required to achieve the project's goals is unknown.

How then does the project manager estimate costs for laboratory work units with any degree of accuracy? A review of Air Force directives and discussions with senior

laboratory management indicates there is virtually no guidance to assist the project manager (17:telephone interview). Thus, the project manager is often faced with estimating the costs of a new project for which the level of effort is not specifically identified and with limited direction or standardized procedures to follow. As with major weapon systems acquisitions, laboratory management also expects the baseline estimate to be accurate as future funding requirements are based on that estimate (9:1, 10:1). For the seasoned project manager cost estimating may not be a significant problem as experience substitutes for the lack of guidance. However, for the inexperienced military or civilian engineer/scientist new to the laboratory environment the cost estimating dilemma may be especially acute.

Problem Statement

Laboratory projects managers have no validated/standardized methods of estimating exploratory development costs.

Objectives

The primary objective of this thesis is to determine what methods, techniques, or guidelines are commonly used in estimating costs for exploratory development projects. The secondary objectives are to:

1. Identify factors which contribute to the variance between the project manager's estimate and the offeror's proposed costs.

2. Identify weaknesses or limitations in the current cost estimating procedures and develop recommendations for improvement.

Hypothesis

The single hypothesis to be tested in this thesis is that formal guidance to assist the project manager in estimating costs for new work units is very limited or nonexistent.

Research Questions

Five research questions will be addressed which supplement the primary and secondary objectives of this thesis. The research questions, which will be identified throughout this thesis by their corresponding numbers, are as follows:

1. Is there a relationship between the type of work unit performed (studies, hardware, or test) and the method employed to estimate costs?

2. Is there a relationship between cost estimating accuracy and the type of work unit performed?*

---

*For the definition of "accuracy" see the section entitled Factors Contributing to Cost Estimating Accuracy and Difficulty in Chapter 3.

3. Is there a relationship between cost estimating accuracy and the number of offerors the project managers generally does business with?

4. Is there a relationship between by accuracy of the overall estimate and the level of detail exercised in estimating the costs?

5. Which cost estimate is generally higher, the project manager's or the offeror's?

Format of Thesis

Chapter 2 develops the methodology used to collect and analyze the data required to determine the cost estimating approaches. The scope of the effort is described which includes discussions of the laboratories participating in the study, data gathering methods considered, and sample size. The rationale for each of the interview questions is then presented in detail and the questions used to address the hypothesis and research questions are identified. The chapter concludes with a discussion of the limitations of the research effort.

In Chapter 3 the responses to each of the interview questions are analyzed and the results discussed. The responses pertaining to the hypothesis and research questions are also addressed and findings reported.

The final chapter, Chapter 4, presents major conclusions drawn from the research effort and based on those conclusions, recommendations for improving the

laboratory cost estimating process. The recommendations are based on both the author's own opinions and recommendations provided by the project managers interviewed.

CHAPTER 2

METHODOLOGY

This chapter discusses the methodology used to collect and analyze the data required to determine the cost estimating approaches employed for Air Force laboratory work units. Initially, the scope of the effort is discussed covering the laboratories participating in the study, data gathering methods considered, sample size, and experience criteria established for the project managers interviewed. Next, the rationale for each of the thirty-five questions is presented in detail and the questions used to address the hypothesis and research questions are identified. Finally, the limitations of the research effort are addressed.

Scope

The data collection method to determine the techniques employed by project managers in estimating costs for new work units was a structured personal interview of selected laboratory project managers. The interview also incorporated questions designed to identify weaknesses in the current cost estimating processes and elicit recommendations for improvement. The interview, consisting of thirty-five questions, can be found in Appendix B.

Several other data gathering methods were considered prior to selecting the interview method. A questionnaire, in which respondents are given a choice of

several alternatives, was rejected. The primary disadvantage of this type of questionnaire was felt to be its lack of flexibility. In some instances a project manager could be forced into choosing a particular alternative, even if it did not apply, for lack of a suitable choice. An open-ended questionnaire requiring project managers to write-in their own response was also ruled out. Due to the time constraints most project managers face, it was felt a limited number of project managers would reply to this type of questionnaire. Thus, the interview was considered the most acceptable method of data collection because: The interviewees were not forced to choose between alternatives; they could be as candid as they desired with their responses; and once agreeing to be interviewed - were committed to completing the interview.

The laboratories selected for this study were the Air Force Armament Laboratory, Eglin Air Force Base, Florida; the Air Force Rocket Propulsion Laboratory, Edwards Air Force Base, California; the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico; and the four component laboratories of the Air Force Wright Aeronautical Laboratories (AFWAL), Wright-Patterson Air Force Base, Ohio, which include the Aero Propulsion, Avionics, Flight Dynamics, and Materials Laboratories. These seven laboratories were selected primarily on the basis of their emphasis on exploratory development work units pertaining

to engineering and the physical sciences. Additionally, the AFWAL were selected because of their proximity to the Air Force Institute of Technology (AFIT).

The single hypothesis to be verified in this study is that formal guidance to assist the project manager in estimating costs for new work units is very limited or nonexistent. The project manager must rely almost entirely on his own experience or, if a novice project manager, the guidance of seasoned project managers or experienced supervisors. The researcher's own three and one-half years of project management experience, preliminary discussions with AFWAL management, and test interviews with five project managers at the Rocket Propulsion Laboratory and the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, provided initial support for the hypothesis. As a result, it was decided that minimum information concerning cost estimating methods could be obtained from inexperienced project managers and the decision was made to interview only those project managers with a specified level of experience.

The criteria qualifying a project manager as "experienced" were:

1. Minimum of three years of project management experience at an Air Force laboratory.

2. Estimated costs for at least three laboratory work units.

For the purpose of this study, project management experience in the context of criteria one, consists of the planning, organizing, and managing the technical and financial aspects of Research and Development (R&D) work units. Furthermore, these criteria were selected in order to include military project managers who generally tend to leave the laboratory at the four year point.

A total of forty-five project managers were interviewed from the seven laboratories with an average of approximately six interviews per laboratory. The specific number of project managers interviewed at each laboratory is found in Table 2-1. During the five test interviews, the quantity of material provided by the project managers and the speed of their delivery precluded manual note taking. Consequently, the majority (43) of the interviews were electronically recorded with a cassette recorder. All project managers were asked their permission to record the interview, prior to starting.

Initially, the AFWAL interviews were conducted in the project manager's office. In those instances, the quality of the recordings varied considerably as a function of background noise and the distance the project managers were from the recorder. To avoid this problem, the remaining AFWAL interviews were conducted telephonically and recorded through the use of a pick-up device. All Armament, Rocket Propulsion, and Weapons Laboratory interviews were also conducted by telephone and recorded.

TABLE 2-1: Interviews per laboratory

LABORATORY	NUMBER
Aero Propulsion	7
Armament	6
Avionics	6
Flight Dynamics	6
Materials	6
Rocket Propulsion	8
Weapons	6
TOTAL	45

MEAN ($\bar{X}$) = 6.4

Again, all project managers interviewed by telephone were asked their permission to record the interview.

The Interview

As stated previously, the interview was designed to determine the cost estimating methods used by project managers, identify weaknesses or limitations in the cost estimating process, and provide recommendations for improvement. This section provides the rationale for each of the thirty-five questions.

Questions 1 through 5 provided demographic data on the experience level of the project managers interviewed, and the R&D category and dollar value of the work units for which costs were estimated. Definitions of the R&D categories of research, exploratory development, and advanced development can be found in the Glossary of Laboratory Terms (Appendix A). Laboratory work units can generally be classified under one of these categories, with the majority classified under exploratory development.

Question 6, the final demographic question, asked the project managers to classify their work units as either studies, hardware oriented, or test oriented. Work units classified as studies are those in which a new concept or variation of an old concept is explored and only a certain level of effort is required. Studies normally do not include fabrication or testing of components and the end items for a study would generally consist of a final

report. Hardware work units are defined, for the purpose of this thesis, as those in which components are fabricated, such as a project where a limited number of novel jet engine compressors are the end items. Test oriented work units would generally consist of projects in which a component or several components are subjected to repeated environmental testing. Thus, the data from Question 6 was used to address the first two research questions:

1. Is there a relationship between the type of work unit performed and the method employed to estimate costs?

2. Is there a relationship between cost estimating accuracy and the type of work unit performed?

Question 7 required the project managers to estimate the number of bidders generally responding to their Requests for Proposals (RFP). The purpose of this question was to address the third research question: Is there a relationship between cost estimating accuracy and the number of contractors the project manager generally does business with? The underlying assumption is that the fewer the contractors the more familiar the project manager becomes with the contractor's method of operation, as well as with the labor and overhead costs.

Question 8 was designed as a broad question to determine the general method or methods project managers used to estimate costs. In order to have the interviewees respond in general terms, they were given five choices of

either historical data, models, handbooks, regulations, or other methods. An alternate motive for using the five choices was to identify specific sources of cost estimating methods or guidelines indigenous to the particular laboratory. If specific methods could be identified they would be combined in a single source. This would provide the inexperienced project managers with a choice of several methods which could be used as given or adapted to suit their particular needs.

Question 9 simply sought to identify the method(s) used to estimate the manpower required to accomplish the objectives of a project. Since labor was assumed to be a major cost factor in most laboratory work units (See Question 20), the labor estimating methods identified through Question 9 could provide valuable information. However, because initial research of current Air Force Regulations, Air Force Systems Command Regulations, and individual laboratory procedures did not reveal any definitive guidance for estimating labor, it was assumed experience or use of historical data would be the major methods employed.

Question 10 was an attempt to determine if project managers estimated labor in detail. At some laboratories the project managers are required to divide the labor estimate into two distinct categories of engineering labor and manufacturing labor. Then, each category must be broken out into numerous education and experience levels.

An excellent example of an education and experience category breakdown can be found in the Air Force Flight Test Center (AFFTC) Form 296, completed by project managers at the Rocket Propulsion Laboratory (See Appendix D). The results from Question 10 would also be one of several questions which address the fourth research question: Is there a relationship between the level of detail in estimating costs and the accuracy of the overall estimate?

Questions 11, 12, 13 and 18 asked the project managers to identify their sources of the various rates, such as labor rates, overhead rates, and general and administrative (G&A) rates. The primary objective of these questions was to determine if laboratories have access to an office or organization that provides rate information or whether project managers are even aware that such an office is at their disposal.

Questions 14, 15, 16 and 17 were incorporated in the interview to determine the estimating techniques employed for other project costs including materials, tooling and special equipment, travel, and computer costs, respectively. It was assumed that a response for each of the four cost items would not necessarily be provided by every interviewee. The assumption was based on the knowledge that some cost items, such as computer or tooling, do not apply to every work unit. Similar to the labor estimate question (Question 8), if specific methods could be identified for these cost items, this study would

combine them in a single source, thus, providing the inexperienced project manager with a choice of methods. However, as with Question 9, it was assumed experience or use of historical data would be the major methods employed.

Question 19 sought to establish if the project manager receives input from potential offerors regarding the overall cost or any specific costs of the work unit under consideration. This question was added after several test subjects indicated open cost discussions with potential offerors produced more accurate cost estimates than when costs were not discussed with potential offerors.

Question 20 asked the project maangers to identify the main cost driver in their work units. The objective of this question was to provide insight as to where project managers might focus their efforts on reducing cost estimating errors. The information would also guide the inexperienced project managers in concentrating on the major cost items when estimating costs. Finally, Question 20 attempted to verify the assumption that manpower is the major cost factor in most laboratory work units (See discussion of Question 9).

Questions 21 and 22 were aimed at determining if the Job Order Cost Accounting System (JOCAS) is a useful cost estimating tool for laboratory project managers. JOCAS is an accounting system prescribed by Headquarters US Air Force (25:1; 5:1). According to Air Force Systems Command Pamphlet 177-3 [3:2]:

> The basic purpose of operating the JOCAS is to identify the total cost of specific efforts and organizations and create a cost consciousness in the R&D manager. Once identified, the cost information has numerous uses including assisting the manager to budget, allocate, recoup, and analyze his initial financial resources.

In addition, Air Force Systems Command Manual 177-265 [5:2] states the information provided by the JOCAS must be used:

> ..... to support job estimating and reimbursement billings and can be used to measure productivity, develop performance and cost standards and to determine where management emphasis should be directed.

Question 21 and 22 are based on the premise that project managers do not use the historical data generated by JOCAS for the purposes described in AFSCP 177-3 and AFSCM 177-265, at least not for contractual work units. The researcher's own experience and similar experiences by project managers participating in the test interviews provided the initial support for the suppositions. If the results support the assumption that JOCAS is not a useful cost estimating tool for contractual work, then laboratory management may consider either updating the system to provide useful cost data or eliminating it entirely for contractual efforts.

Question 23 was made a part of the interview to ascertain if project managers use any particular form or format to either assist or to record their estimates. The rationale behind this question is that the use of these forms force the project manager to break out costs for items such as labor, overhead, materials, and travel. As a result, the overall estimates are more accurate and

provide a baseline departure point for evaluating a bidder's proposal. Responses to this question, in conjunction with the responses to Question 10, help to answer the fourth research question stated previously.

Question 24 is a continuation of Question 23 and was asked to determine if the project manager retains the initial cost estimate for future reference. Retention of the estimate would be beneficial for several reasons:

1. The old estimate could help in estimating costs for a new work unit of a similar nature.

2. The estimate could serve as a baseline for evaluating an offeror's proposal.

3. Retention of the estimate is required by Air Force Systems Command and laboratory directives (1:1; 7:1; 9:1; 10:1).

Questions 25, 26, 27, and 28 all pertain to the variances between the project manager's cost estimate and the project costs proposed by the bidders. Question 25 attempted to establish the general magnitude of the variance. The responses to this question would also provide the data to answer the fifth research question: Which cost estimate is generally higher, the project manager's or the offeror's? Based on the researcher's experience and responses of the test subjects the assumption was made that the offeror's costs would generally be higher.

Question 26 was considered to be one of the more important questions of the interview, in that the responses would provide valuable insight as to the causes of the variance. If, in fact, project managers are repeatedly incorrect in their estimates by 10% or more, budgeting funds for outyear programs becomes difficult for laboratory management. Thus, for planning purposes, the laboratories should benefit if causes of variance are identified and the solutions result in decreasing the variance magnitude.

The test interview responses to Question 26 prompted the incorporation of Question 27. Four of the five test interviewees indicated misinterpretation of the Statement of Work (SOW) was a contributing factor to the variance between their estimate and the bidder's proposed costs. If a large majority of the forty-five project managers considered misinterpretation of the SOW to be a problem, then perhaps, project managers and laboratory management should focus on producing SOWs whose content and phraseology clearly define the objectives, scope, and performance requirements of the effort.

Question 28 attempted to ascertain if project managers make a concerted effort to determine where the variances exist between their estimate and those of the bidders. This question was developed on the assumption that identification of past variances would reduce future variances.

Question 29 was added to the interview to determine if project managers compared their original estimate and/or the offeror's original estimate to the final cost of the contract. If an offeror's proposed costs are sufficiently high, such that the project cannot be funded, then the costs are negotiated between the government and the bidder. Some project managers claim knowledge of instances where the offeror's reduce their proposed costs in order to remain competitive, knowing their proposed level of effort cannot be completed at the new cost without a cost growth or overrun. This situation is often refered to as "buying in" to a project. If project managers do, in fact, compare the original estimates with the actual costs, it was desired that additional information about the "buying in" practice could be obtained.

Questions 30 and 31 simply attempted to establish if project managers are satisfied with the information and/or tools at their disposal to estimate costs and if they have adequate time to prepare the estimates. The primary objective of Question 30 was to specifically identify the information project managers felt was lacking or the tools they would like to have available. Question 31 was inserted as a result of some test interview responses indicating sufficient time was not available to perform an adequate cost estimate.

Question 32 sought to determine if project managers purposely estimate costs conservatively or add

a contingency factor to their estimates. Such practices could avoid the embarassement of continually underestimating project costs. Because of the assumption that bidders generally propose higher costs than the project manager's estimate (See discussion of Question 25), this question was added to determine how project managers compensate for the variance if their estimates are repeatedly low. If numerous project managers resort to the use of a contingency factor, a secondary objective of Question 32 was to establish the specific factors currently being used.

Question 33 asked the project managers if they were constrained by earlier cost estimates, such as those made during the planning cycle. Within the AFSC laboratories planning for new programs, as a rule, occurs several years prior to the actual start of the project. During the planning cycle project managers propose new projects they feel would advance technology or solve a current military problem. At this time the project manager is also required to provide an estimate of the project costs. With this planning scenario in mind, two assumptions concerning the original estimate are made. The first is that, in many instances, these estimates are made in haste due to time pressure resulting from increased workload of the planning period. Several years later, when funding becomes available the project manager performs another estimate, often in considerable detail.

Due to industry rate increases and inflation during the interim period or as a result of a more realistic estimate, the original cost assessment may differ substantially from the second estimate.

The second assumption is that project managers are forced to abide by the original estimate due to budgetary constraints. Consequently, the scope of the effort must be reduced or, if the project is funded at the higher cost, the project must be extended over a longer time frame. Thus, the overall costs increase. Question 33 attempted to determine if the above scenario does occur and if project managers consider the situation a problem worthy of management attention.

Questions 34 and 35 were expected to provide the most useful information generated by this study. The project managers were provided an open forum to discuss their perceptions of the weaknesses in the cost estimating process. In addition, they were given the opportunity to make recommendations for improvement. The objective of these questions was not to find fault with any particular laboratory but to determine common problems encountered by project managers from diverse laboratories and provide common solutions or recommendations.

Data Analysis

The responses to the questions were tabulated and compared to determine the common methods used to estimate

total project costs and the various cost components. The same approach was used to answer the single hypothesis, the research questions, and assumptions. Finally, the problems, weaknesses, and limitations identified by the interviewees and recommendations for improvement are listed.

Due to the non-numerical nature of the majority of the data statistical analysis was not conducted, with the exception of simple mean (average) calculations. Linear regression and correlation analysis was not conducted.

Limitations

Limitations with regards to the scope of the research effort and the methodology by which the data was collected and analyzed are discussed in the following paragraphs.

This study was not an attempt to arrive at a universal cost estimating method applicable to all Air Force laboratories, nor was the objective to solve all the problems of the cost estimating process. From the onset, it was realized that each laboratory has a unique mission and has some autonomy in the manner in which it conducts its day-to-day operations. After conducting interviews with several individuals in one laboratory it became apparent that procedures even vary between divisions within a laboratory. Therefore, this thesis effort was conceived as an initial investigation that would pave the way for a series of follow-on research efforts. It is the desire of

this author that further research efforts, such as the AFIT thesis program, continue this effort with the end product being a simple cost estimating model or technique applicable to the majority of the Air Force laboratories.

The second limitation concerns the approach used to gather data. As discussed earlier in this chapter, the use of a questionnaire was rejected because the method lacked flexibility. While the interview method has the distinct advantage of being flexible, the disadvantage lies with the diversity of the responses. Thus, some of the data cannot be neatly grouped into a set of clear-cut responses from which general observations can be derived. As an example, Question 26 attempts to establish the major factors that contribute to the cost variance between the project manager's estimate and the bidder's proposed costs. The summary of responses for Question 26 in Appendix C lists 14 separate responses. Obviously, with so many varied answers, only the most general conclusions can be drawn. Only through sampling of a very large population could the major factors be separated from the less significant ones. However, the time consuming nature of the interview (15-30 minutes) precluded interviewing a large number of project managers.

Another limitation concerns the interview method itself. Again, it was mentioned earlier in this chapter that the majority of project managers were interviewed by telephone. The use of this method resulted in clear,

static free recordings. However, interviews by telephone could have resulted in less than candid responses. Two project managers refused to be interviewed by telephone because they could not verify the researcher's identity. After being interviewed in their offices they informed the researcher that they feared a potential contractor, posing as an AFIT graduate student, was attempting to gather sensitive information concerning government cost estimating procedures or procurement practices. Therefore, they would not conduct the interview by telephone. While, the researcher always clearly identified himself and the individual who recommended the project manager to be interviewed, doubt concerning identity could still remain. Consequently, all interviewees may not have been completely straightforward or honest with their responses.

The final limitation is that two cost items generally associated with laboratory work units, were inadvertently omitted from the interview. The items were subcontracting costs and fee. However, none of the forty-five project managers indicated subcontracting costs or fee was a major cost driver in their work units (See Question 20, Appendix C). In addition, only two project managers said fee or subcontracting costs were a primary factor for the variance between their estimates and the offeror's costs (See Question 26, Appendix C). Therefore, it appears exclusion of these two cost items did not degrade the quality of research by any significant degree.

Summary

This chapter presented the methodology used for collection and analysis of the data necessary to determine the approaches commonly used in estimating costs for Air Force laboratory projects. The scope of the effort was discussed including the laboratories participating in the study, the data gathering methods considered, sample size, and experience criteria required. The rationale for each of the questions was then presented and the questions used to address the hypothesis and research questions were identified. As a final item, the limitation of the research effort were addressed.

CHAPTER 3

RESULTS AND FINDINGS

Introduction

In this chapter the responses to the 35 interview questions are analyzed and the results discussed. A detailed summary of each question is available in Appendix C and abbreviated summaries are presented in this chapter as required. Additional tables and graphs comparing various answers and supporting the hypothesis and research questions are also provided.

Demographics

Questions 1 through 6 were incorporated into the interview to gather demographic information on the population of project managers interviewed. Question 1 sought to establish the grade/rank structure of the interviewees. As anticipated, experienced military project managers were not as numerous as their civil service counterparts. Of the forty-five project managers interviewed, exactly one-third were military and the remaining civil service. The rank mix of the military project managers consisted of approximately one-half (53.3%) captains with the balance divided almost equally between first lieutenants and majors. There were no project managers below the grade of first lieutenant

or above the grade of major interviewed.* The majority (23) of the thirty civilian project managers interviewed held the grade of GS-13. The remainder consisted of three GS-12s and four GS-14s. No project managers below the grade of GS-12 or above GS-14 were interviewed.

All respondents satisfied the experience criteria of three years of project management responsibility at an Air Force laboratory and having estimated costs for a minimum of three laboratory work units. If either criteria was not met, the interview was terminated. Most project managers had considerably more years of project management experience than was required. More than 75% had at least five years of experience and more than 50% had been laboratory project managers for 15 years or more. However, the military respondents were the least experienced as shown in the summary of Question 2 in Appendix C. The average number of years of project management for this group was 5.3 years compared with 16.9 years for the civilian respondents. Only two project managers estimated costs for the minimum of three work units while 64.4% estimated costs for ten or more work units during their years as

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*Second lieutenants and civilians below the grade of GS-12 were not specifically excluded from this study. In all instances the interviewees were recommended by supervisors or project managers who had participated in the interview. Two second lieutenants were recommended but did not satisfy the experience criteria. As a result, their interviews were terminated after Question 3.

project managers. The two managers with the minimum of cost estimating experience were both military, one first lieutenant and one captain. However, the remaining military, excluding these two, had considerably more experience with a mean of 17.5 work units.

In Chapter 1 it was observed that cost estimating in Air Force laboratories is difficult because of the uncertain nature of the work units. The projects consist of studies and investigations which often lack specific requirements or specifications and result in either advancing the state-of-the-art and/or resulting in a one-of-a-kind end item. Therefore, based on the definitions in AF Regulation 80-1 (26:2) and AFSC Regulation 80-21 (2:1), it was assumed that the majority of laboratory work units could be classified under the R&D category of exploratory development. This assumption was verified by the responses to Question 4, summaried in Appendix C. While most project managers indicated they had managed combinations of research, exploratory development, and advanced development work units, the majority said their primary emphasis was on exploratory development projects.

While the responses to Question 4 revealed exploratory development work units predominated, it was more difficult to ascertain whether the work units were primarily of a studies, hardware, or testing nature. Approximately 69% of the respondents indicated their work units were not of any one type, rather they managed or

had managed various combinations of studies, hardware, or test projects. Only 14 interviewees had not managed combinations; seven classified all their work units as studies, four as hardware oriented, and three as test oriented. Consequently, it was difficult to answer the first two research questions. The research questions and Question 6 are discussed in more detail in the following two sections of this chapter.

The final background question asked the respondents to give the average dollar value of their work units (Question 5). This question was intended to furnish the researcher with a general knowledge of the funds required to conduct laboratory work units. Most project managers were unable to respond with an average value because of the diverse dollar range of their projects. Therefore, many responded with that particular range. The only generality gleaned from the responses is that the majority of work units were valued at one million dollars or less. Only three project managers indicated they consistently managed projects in excess of one million dollars.

Cost Estimating Methods and Techniques

In this section the responses to the various questions regarding cost estimating methodology and techniques, as well as the sources for some of the more important rates, are analyzed. In conjunction with the

analysis, the hypothesis concerning the availability of formal cost estimating guidance will also be addressed. Finally, this section addresses the first research question: Is there a relationship between the type of work unit (study, hardware, or test) and the methods used to estimate costs?

Before attempting to ascertain cost estimating techniques for any specific cost item, the project managers were first queried about their general or overall cost estimating methods. The responses to Question 8 provided the desired information and also addressed the hypothesis that limited formal cost estimating guidance is available to the project managers. The responses to Question 8 are summarized in Appendix C, and Table 3-1 furnishes a concise listing of methods with the "experience" and "engineering judgment" responses combined. It should be noted that many project managers used a combination of methods, therefore, more than 45 responses were recorded.

The hypothesis that limited formal cost estimating guidance is available, and if available, is not used by project managers was verified by the results. Only a very small percentage (6.7%) of the respondents used any formal guidance and those who did, indicated their primary method was the use of historical data from past projects or recent cost proposals. The three respondents using pre-RFP estimates provided by contractors also stressed historical data or experience were their primary cost estimating

Table 3-1: General Cost Estimating Methods

Method	Responses	Percentage of the 45 Respondents (%)
HISTORICAL DATA	35	77.8
EXPERIENCE/JUDGMENT	20	44.4
GUIDANCE FROM EXPERIENCED PROJECT MANAGERS	6	13.3
LOCAL GUIDELINES	3	6.7
PREPROPOSAL ESTIMATES BY BIDDERS	3	6.7
LOCAL FINANCIAL ANALYSIS OFFICE	1	2.2
TOTAL	68	

NOTE: Some project managers used combinations of methods to estimate overall costs, therefore, the responses do not total to 45.

techniques. The lone project manager whose estimates of work units over $500,000 were made by the financial analysis office at his laboratory, said previous experience and similar past projects were his techniques for estimating costs of smaller contracts. He also mentioned that he did not feel the estimates made by the financial office were any more accurate than an estimate made by a project manager with 15 years of experience. Therefore, the data indicates that while some project managers use formal guidelines or outside sources, experience and data from past work units are the primary methods of estimating costs at the Air Force laboratories involved in this study.

The second purpose for Question 8 was to identify specific formal cost estimating guidelines and methods so that they could be combined into a single source. This compendium of guidelines would provide the inexperienced project manager with a repertoire of methods from which to choose. Unfortunately, of the three project managers who used guidelines, two were from the same laboratory and used the identical guidance. Consequently, only two methods were actually identified and, even then, were very limited in guidance. (The two guidelines can be found in Appendix D.) The guidelines consisted primarily of instructions on completing forms which contained numerous cost items or guidance on the type of costs to consider in an estimate. Neither gave information on the specific procedures required to estimate labor, materials, travel, etc. Thus, one of

the research objectives, to provide multiple cost estimating sources was not achieved.

As stated in Chapter 2, if formal guidelines were limited for overall cost estimating, it was assumed that very limited guidance would be available for estimating labor, and that experience and historical data would be the prevalent methods employed. The responses provided by the project managers interviewed are summarized under Question 9 in Appendix C and in a condensed listing in Table 3-2. From Table 3-2 it is easily discernible that experience/judgment or a combination of historical data and experience/judgment are the primary cost estimating techniques used by the 45 project managers. Consequently, the data supports the assumption.

The summary of Question 9 in Appendix C lists eight different responses while only five methods are listed in Table 3-2. The detailed breakout is given in Appendix C to draw attention to the fact that while experience and/or historical data are the main factors in estimating labor, there are different methods employed within the realm of experience and historical data. For example, at first glance responses a., d., and f. may appear to be quite similar. However, response d. differs from a. in that d. is a more detailed estimate. The respondents who answered with response d. broke their work units into subtasks, similar to a Work Breakdown Structure (WBS), and estimated manhours for each subtask. This estimate differs from the

Table 3-2: Manpower Estimating Methods

Method	Responses	Percentage of the 45 Respondents (5)
EXPERIENCE/JUDGMENT ONLY	7	15.6
HISTORICAL DATA AND EXPERIENCE/JUDGMENT	37	82.2
GUIDANCE FROM EXPERIENCED PROJECT MANAGERS	1	2.2
PREPROPOSAL ESTIMATES BY BIDDERS	4	8.9
OTHER	3	6.7
TOTAL	52	

NOTE: Some project managers used combinations of methods to estimate labor, therefore, the responses do not total to 45.

total work unit estimate of labor conducted by the a. respondents in the level of detail performed. The f. responses differ from both a. and d. in that the estimate is made in terms of manyears rather than manhours. The manyear estimate, as defined by the project managers interviewed, differs in two primary aspects from the manhour estimate:

1. The manyear estimate is a very "rough order of magnitude" estimate (even less detailed than the a. type).

2. The manyear estimate, when translated into dollars, includes all costs such as overhead, General and Administrative, and fee.

If the answer to the fourth research question indicates that detailed cost estimates are more accurate than cursory estimates, which are discussed in the following section, then the difference in methods of estimating labor could have some importance. Another point to consider when comparing manyear estimates with detailed ones is that the former estimate may be biased by overhead rates which can vary significantly from one contractor to another.

Some project managers who estimated labor via manyears provided additional information. Eight of the respondents identified their manyear rates which are listed in Table 3-3. Two respondents provided a rate for university work units as well as an industry rate. The mean industry rate was calculated by taking an average of the two range values for each range response, and then averaging the eight

Table 3-3: Manyear Rates Used by Project Managers

University Rate (Thousands $)	Industry Rate (Thousands $)	Responses
-	80	2
-	100	2
60	100	1
50	200	1
-	80 - 100	1
-	100 - 125	1

AVERAGE INDUSTRY MANYEAR RATE $108,000

AVERAGE UNIVERSITY MANYEAR RATE $ 55,000

separate values. It is interesting to note the mean university rate is approximately half the industry rate.

In Chapter 2 the assumption was made that labor is a major cost factor in most laboratory work units, and if correct, the methods identified in estimating labor would be of significant importance. The summary of Question 20 in Appendix C clearly supports the assumption. A total of 37 respondents (82%) indicated manpower to be the primary cost factor and another four (9%) specified labor, in conjunction with another factor (overhead or hardware), were the major cost drivers. Unfortunately, the responses to Question 9, discussed above, reveal there are no documented labor estimating techniques available. Therefore, inexperienced project managers must rely almost entirely on the guidance provided by the seasoned project manager when estimating labor. Even if novice project managers have access to historical data, they must have the experience to discern which data is relevant to the new work unit.

With the establishment of experience and use of historical data as the primary general estimating techniques, the research focused on methods used to estimate specific cost items. The specific items investigated were materials, tooling and special equipment, travel, and computer costs via Questions 14, 15, 16, and 17, respectively. As anticipated, the estimating methods were of an informal nature and experience and use of past projects or proposals predominated.

The methods used to estimate material costs are presented in Appendix C under Question 14 and a condensed listing in Table 3-4. More than 50% of the respondents relied on historical sources and their own experience or judgment, and another 20% combined historical data with an inflation factor or information from handbooks or vendor's catalogs. Specific catalogs were not identified, however, three project managers provided specific inflation factors. One diligent project manager used the inflation factor provided by the U. S. Bureau of Labor Statistics (11:144). Employment and Earnings is a monthly publication that lists inflation factors for different industries, such as aerospace, heavy industry, and electronics.

Tooling or special equipment costs was not a work unit cost factor for many of the respondents as shown in the responses to Question 15 in Appendix C and Table 3-5. More than 66% disregarded tooling or special equipment costs when making an estimate or lumped the costs together with the total manyear dollar value. However, of the 15 project managers who did consider these costs in their estimates, 13 relied on historical data or experience/judgment. The best guess, gut feel, and rules of thumb responses were combined with the experience/judgment factors in Table 3-5.

The methods for estimating computer costs were similar to the previous two cost items. Again, more than half of the project managers relied on their own experience, historical data, or a combination of historical data plus

Table 3-4: Materials Costs - Estimating Methods

Method	Responses	Percentage of Total Responses (%)
HISTORICAL	13	28.9
HISTORICAL PLUS INFLATION FACTOR	5	11.1
HISTORICAL PLUS HANDBOOKS OR VENDOR CATALOGS	4	8.9
EXPERIENCE/JUDGMENT	11	24.4
OTHER	4	8.9
NOT APPLICABLE	8	17.8
TOTAL	45	100.0%

Table 3-5: Tooling and Special Equipment Costs - Estimating Methods

Method	Responses	Percentage of Total Responses (%)
HISTORICAL	5	11.1
EXPERIENCE/JUDGMENT	8	17.8
OTHER	2	4.4
NOT APPLICABLE	30	66.7
TOTAL	45	100.0%

estimates made by the local computer center or analysis group to estimate computer costs. Table 3-6 lists the methods employed and a detailed summary is given in Appendix C under Question 17. All seven of the laboratories participating in this study had either an analysis section or a local computer center that is capable of estimating computer costs for a new project. Surprisingly, only a very small percentage of the project managers utilized these readily available sources. Instead, they chose to rely on less analytical methods to estimate their computer costs. It would appear that these sources are not used because the relatively small computer costs, as compared to the overall work unit costs, do not warrant the project manager's time to obtain the estimate.

The final specific cost item explored in this study was travel costs. The summary of the responses is also presented in Appendix C under Question 16. Thirty-five of the 45 respondents estimated travel costs in considerable detail. The majority estimated the number of trips required, the number of personnel per trip, and a per diem rate. In addition, many project managers called airline ticket offices for current air fares and estimated rental car expenses. One would anticipate that estimating in such detail would result in rather accurate estimates. However, travel costs are generally a small percentage of the total work unit costs. While no specific data was collected to substantiate this statement, the researcher's own experience

Table 3-6: Computer Costs - Estimating Methods

Method	Responses	Percentage of Total Responses (%)
HISTORICAL	13	28.9
COMPUTER CENTER	6	13.3
HISTORICAL PLUS COMPUTER CENTER	7	15.6
EXPERIENCE/JUDGMENT	5	11.1
OTHER	2	4.4
NOT APPLICABLE	12	26.7
TOTAL	45	100.0%

and similar responses from many of the interviewees supports the assumption. Thus, the question arises as to why detailed estimating is conducted for an inconsequential cost item, such as travel, and crude estimates are made for a major cost item, such as labor. Unfortunately, the data generated by this study does not provide the answer.

The previous paragraphs focused on cost estimating methods for specific cost items. Of equal importance in the estimating process are the rates used to determine labor costs, overhead, and General and Administrative (G&A) costs. As stated in Chapter 2, Questions 11, 12, 13, and 18 were used in the interview to determine if laboratories have a financial analysis office or a local procurement organization which identifies the various rates. Discussions with management, at those laboratories, of which the researcher did not have personal knowledge, revealed that all laboratories studied did, in fact, have such organizations. In some instances these offices/organizations also categorized the rates by industries (aerospace, electronics, etc.) and calculated average rates. Therefore, local rate sources were available to the project managers interviewed.

The second objective of Questions 11, 12, 13, and 18 was to determine if the project managers utilized the rate information or were even aware the information was available. The summarized responses in Appendix C provide the answer. Only 35.6%, 33.3%, and 33.3% of the respondents relied exclusively on rates provided by local

organizations for labor, overhead, and G&A rates, respectively. Three to four respondents used the information generated by the local organizations in combination with other inputs, but many chose to rely on historical data alone. Several reasons can be postulated for the non-utilization of the rate information:

1. Project managers are not aware the rate information exists.

2. Project managers are aware of the rate information but elect not to use it.

If either or both of the above reasons are valid, laboratory management should conduct additional research to establish why project managers are ignorant of the information or why they do not use it.

The final issue addressed in this section is whether a relationship exists between the type of work unit performed (studies, hardware, or test), and the methods employed to estimate various costs (Research Question 1). Table 3-7 lists the methods used by project managers to estimate costs for the three types of work units. The data are tabulated for the overall or general costs and for the five specific costs discussed previously. As mentioned in the Demographics section, the majority of the respondents managed combinations of studies, hardware, or test projects, therefore, data for specific types of work units was scarce. Due to the limited data, a relationship between the type of work unit and the

Table 3-7: Type of Work Unit Versus Estimating Methods Used

* S = Studies
H = Hardware
T = Test

Methods	Type of Work Unit																		
	General			Labor			Mat'ls			Tooling & SE			Travel			Computer		
	S*	H	T	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T
HISTORICAL	5	1	2	3	1	2	2	1		1	1			1		2	1	
EXPERIENCE	2		1	4	2		2	1	1			1						
HISTORICAL/ EXPERIENCE		1																
HIST/EXP + INFLATION FACTOR		2																
AVAILABILITY OF FUNDS					1	1												
PERCENTAGE OF TOTAL							1											
VENDOR CATALOGS								1										
CONTRACTOR											1							
NUMBER OF TRIPS, ETC.													6	2	2			
$1000 PER TRIP													1	1				
COMPUTER CENTER																1	1	1
HISTORICAL + COMPUTER CENTER																1	1	
NOT APPLICABLE							2	1	2	6	2	2			1	3	1	2

estimating method was difficult to establish. The only conclusion to be drawn from Table 3-7 is that historical data and experience appear to be the predominant methods used to estimate general, labor, and materials costs for studies type work units. Since studies generally do not require manufacturing of hardware, the logic behind the nonapplicability of tooling/special equipment costs to studies work units is clear. In addition, the detailed estimating of travel costs for studies projects follows the trend discussed in a preceeding paragraph. Again, the data base for respondents who managed strictly hardware or test projects was severely limited. Consequently, a relationship between the estimating techniques used and these two types of work units could not be established.

This concludes the analysis and discussion of the cost estimating methods and techniques employed by laboratory project managers. In summary, the data indicates that project managers rely on experience and use of past projects or proposals rather than on formal methodologies for estimating specific cost items. The next section investigates the factors contributing to accuracy of cost estimates and the difficulty in making the estimate.

Factors Contributing to Cost Estimating Accuracy and Difficulty

In this section the remaining four research questions are investigated:

- Which cost estimate is generally higher, the project manager's or the offeror's? (Research Question 5)

- Is there a relationship between cost estimating accuracy and the number of contractors the project manager generally does business with? (Research Question 3)

- Is there a relationship between the level of detail involved in estimating costs and the accuracy of the overall estimate? (Research Question 4)

- Is there a relationship between cost estimating accuracy and the type of work unit performed? (Research Question 2)

Other issues addressed will be the factors contributing to cost variance, as identified by project managers; the use of contingency factors to compensate for the variance; and an attempt to determine if "buying in" is a problem within Air Force laboratories.

For the purpose of this study accuracy is defined as the difference in costs between the project manager's estimate of costs and the costs proposed by potential offerors. This discrepancy between estimates will be refered to as "variance." The variance, given as a percentage rather than a dollar value, was not verified by actual data. Project managers were asked to give a spontaneous estimate of the difference; they did not check project files to confirm the values.

Question 25 was the vehicle used to identify this variance. The responses to this question are the only

data used to gauge the accuracy or difficulty of cost estimating and is the key data used to address Research Questions 2, 3, and 4. However, because the variance is a "best guess" response only general observations can be made on the basis of the data; firm conclusions or concrete answers to the research questions cannot be made.

To determine which cost estimate, the offeror's or the project manager's, is generally higher (Research Question 5) the responses to Question 25 were studied. The responses are summarized in Table 3-8 and a detailed break-out can be found in Appendix C. In Table 3-8 the variances are listed under two categories. The first category applies to those responses which indicated the offeror's costs are generally higher than the project manager's estimate. If the respondents indicated the offeror's costs were sometimes higher and sometimes lower (evenly distributed) then the response was classified under the second category.

The data suggests that offeror's costs are generally higher than the project manager's projected costs. Sixty percent (27 responses) of the respondents said the bidder's costs were generally higher while only 22.2% indicated the variance was evenly distributed. The remaining 17.8% (8 responses) did not provide a specific response. The data also indicate that the variance magnitude, in most cases, does not exceed 30%. Thus, two general observations can be made:

Table 3-8: Cost Variance Between Project Manager's Estimate and Offeror's Estimate

OFFERORS'S ESTIMATES NORMALLY HIGHER

Variance (Percentage, %)	Responses
0 - 10	4
10 - 20	12
20 - 30	8
30 - 40	1
40 - 50	1
50 or greater	1
TOTAL	27

OFFEROR'S ESTIMATES EVENLY DISTRIBUTED

Variance (Percentage, %)	Responses
0 - 10	3
10 - 20	3
20 - 30	2
30 - 50	1
30 or more	1
TOTAL	10

No specific percentage given - 8 responses

1. The offeror's proposed costs are generally higher than the project manager's estimate.

2. The magnitude of variance is generally less than 30%.

Of course, the "best guess" nature of the responses to Question 25 must be considered. Any firm conclusions would require additional research in which the variance magnitudes were verified.

Question 7 was the first nondemographic question which attempted to gain insight into the accuracy of the cost estimating process. The project managers were asked to provide an estimate of the number of bidders that generally respond to their RFPs. The responses to this question were used to determine if a relationship exists between cost estimating accuracy and the number of contractors the project manager generally conducts business with (Research Question 3). As the number of contractors increase it was assumed the accuracy decreases, because the project managers are less able to familiarize themselves with the bidders' methods of conducting business and the bidders' labor and overhead rates. An underlying assumption should also be noted at this point; the project manager repeatedly has the same three, four, or five bidders respond to an RFP. If a project manager had bidders A, B, and C respond to an RFP he would have A, B, and C again respond to the next RFP. There would not be a completely different group of contractors D, E, and F, for

example, respond to the next RFP. Through discussions with the project managers interviewed and the researcher's own experience, this situation of repeated contractors appears rather commonplace.

By comparing the responses to Question 7 with the variance reported between the project managers estimate and the costs proposed by the bidder (Question 25), it was possible to draw a general conclusion. Table 3-9 lists the cost variances reported by project managers who normally have as few as three and as many as ten bidders respond to their Requests for Proposals. Only the responses of project managers who gave a specific number of bidders responding to an RFP, rather than a range, were used. The numerical range responses were deleted because of the wide spread within some of the ranges, such as one to ten or six to fifteen. An examination of Table 3-9 reveals the variance to be relatively small for the eight project managers who said they generally had only three bidders respond to their RFPs. However, as the number of contractors increased to four and then five, the variance increased, indicating a direct relationship between the number of bidders and the variance. Unfortunately, beyond five bidders the data are scarce and no conclusions can be drawn. The bar chart in Figure 3-1 also graphically depicts the variance spread increase with succeeding increases in bidders. Thus, based on this rather limited data, it appears an inverse relationship exists between the number of offeror's generally responding

Table 3-9: Contractors Responding to RFP and Magnitude of Variance Reported by Project Managers

Number of Contractors Responding to RFP	Variance Between Project Manager's Estimate and Costs Proposed by Bidders (Percentage)
3	10 - 15 (H)[1] 10 - 20 (H) 10 - 20 (H) 10 - 20 (H) 20 (H) 25 (H) 25 - 30 (H) 20 - 40 (H)
4	5 - 10 (H) 5 - 20 (ED)[2] 10 (H) 15 (H) 25 (H) 25 (H) 25 (H) 30 (H) 50 or more (H) Relatively Close Not Certain
5	10 (ED) 10 (ED) 10 (ED) 30 - 50 (ED) 30 Below to 100 Above Quite Often High
6	25 - 30 (H) 30 (H) 100 - 200 (H)
7	20 (H) 20 - 25 (H)

Table 3-9: Continued

Number of Contractors Responding to RFP	Variance Between Project Manager's Estimate and Costs Proposed by Bidders (Percentage)
9	30 (ED)
10	15 - 20 (H)

TOTAL RESPONSES - 33

[1] Bidder's costs are generally higher.

[2] Variance is evenly distributed.

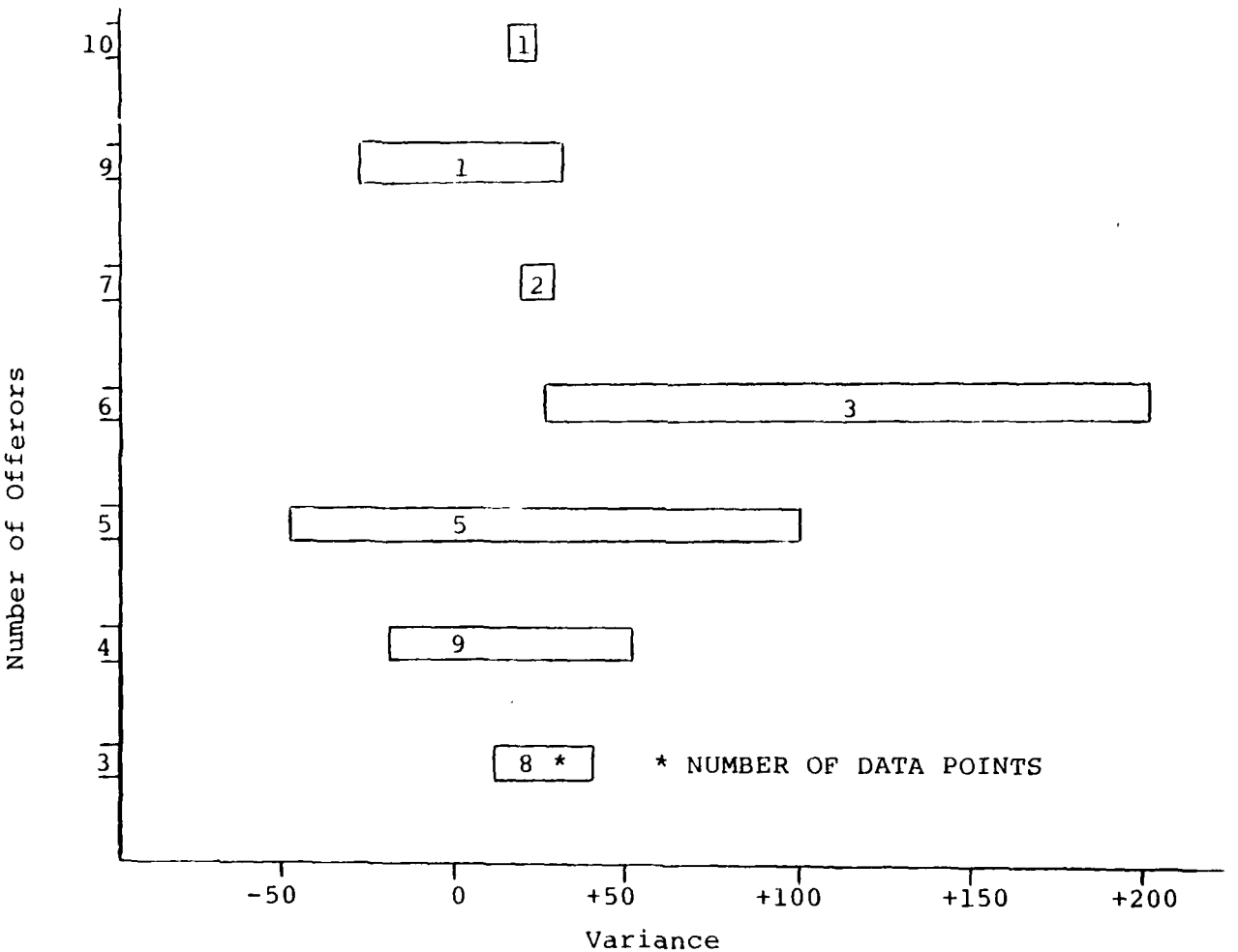


Figure 3-1: Bidders Responding to RFP vs Range of Variance Between Project Manager's Estimate and Bidders Proposed Costs

to an RFP and the accuracy of the project manager's estimate. The caution that the variance data is based on unvalidated responses must again be reiterated.

Research Question 4 was also aimed at determining accuracy factors. The research question was designed to determine if a relationship exists between the level of detail involved in estimating costs and the accuracy of the overall estimate. Two diametric viewpoints concerning detailed estimating and its effect on estimate accuracy can be made. First of all, the argument can be made that a direct relationship exists between detailed estimating and accuracy. A project manager who estimates in detail will have less variance in his work units because the uncertainties resulting from a cursory estimate are reduced. On the other hand, one can contend that when making detailed estimates, errors occur in each subestimate and the resultant aggregate estimate with the accumulated errors will be considerably off its mark (14:77).

Three interview questions addressed the issue of detailed estimating and its relationship to estimate accuracy. Question 10 asked the project managers if they divided their labor estimates into various education and/or experience categories. The underlying assumption was that a break out of labor into these separate categories required a certain amount of detailed estimating. Question 23 asked the respondents if they used a local form or format to either assist in making or recording their estimate. As stated in

Chapter 2, the rationale behind the question is that the use of forms, such as the AFFTC 296, force the project manager to break out several cost items; thus, indicating that the estimate is made in detail. The third question (Question 25) provided the accuracy data via the variance responses.

The detailed responses to Question 10 are presented in Appendix C and a tabulated summary is given in Table 3-10. Table 3-10 lists the variance reported by those respondents who subdivided their labor estimates into education and/or experience categories as well as those who did not. The data indicates that project managers who subdivide their labor also reported higher variance. More than 30% of the "yes" respondents said their variance was between 30-40% while only 13.3% of the "no" respondents reported variances of that magnitude. Additionally, 16.6% of the "yes" respondents reported variances in excess of 30%. However, none of the "no" respondents reported variances above 30%. Finally, 73.3% of the "no" respondents indicated their variance was generally less than 20%. Therefore, if subdivision of labor can be interpreted as estimating in detail, then the data indicates an inverse relationship exists between detailed estimating and accuracy. The greater the level of detail project managers exercise in their estimates, the less accurate the estimate becomes.

The results of Question 23 presented in Table 3-11 reveal similar results. Those project managers who used either a local form or the DD 633-4 reported higher variances

Table 3-10: Accuracy as a Function of Detailed Estimating (Labor Subdivided Into Education and Experience Categories)

Variance (%)	Is Labor Subdivided?			
	Yes		No	
	Responses	Percentage of "Yes" Response	Responses	Percentage of "No" Response
0 - 10	4	13.3	3	20.0
10 - 20	7	23.3	8	53.3
20 - 30	9	30.3	2	13.3
30 - 40	1	3.3	-	-
40 - 50	-	-	-	-
50 or more	4	13.3	-	-
No Factor	5	16.7	2	13.3
TOTAL	30	99.9%*	15	99.9%*

*Percentages do not sum to 100% because of rounding.

Table 3-11: Accuracy as a Function of Detailed Estimating (Estimating Form Used)

Variance (%)	Estimating Form Used?					
	"Yes" (Local)		"Yes" (DD-633-4)		"No"	
	Responses	% of "Yes" Responses	Responses	% of "Yes" Responses	Responses	% of "No" Responses
0 - 10	2	10.5	1	16.7	4	20.0
10 - 20	7	36.8	1	16.7	7	35.0
20 - 30	6	31.6	2	33.3	3	15.0
30 - 40	-	-	1	16.7	-	-
40 - 50	-	-	-	-	-	-
50 or more	2	10.5	1	16.7	1	5.0
No Factor	2	10.5	-	-	5	25.0
TOTAL	19	99.9%*	6	100.1*	20	100.0%

*Error due to rounding.

than those respondents who did not use a form. While the results are not as pronounced as those shown in Table 3-10, the same general trend can be seen. The data also reveal that of the 30 project managers who subdivided labor, 20 (66.7%) also used some form, either local or the DD 633-4. Of the 15 project managers who did not subdivide labor only 5 (33.3%) used some type of form. Thus, two observations can be made from the results of Questions 10, 23, and 25:

1. Detailed estimating appears to decrease overall accuracy.

2. Project managers who do not subdivide labor also tend not to use forms or formats to assist in making or recording their estimates.

In order that the above observations are not construed as firm conclusions, the caveat that the variance data is based on unvalidated responses is reiterated.

The next question concerning estimate accuracy sought to establish if cost information provided by potential offerors decreased the variance. In Chapter 2 it was stipulated that Question 19 was added after several of the test subjects indicated open cost discussions with potential offerors produced more accurate cost estimates. The responses tabulated in Table 3-12 tend to support this observation. The percentage of responses for the variance ranges of 0-10% and 20-30% were quite similar for both the "yes" and "no" respondents. In the variance range of 10-20%, however, the percentage of "yes" responses were more than double those

Table 3-12: Accuracy as a Function of Contractor Input to Estimate

Variance (%)	Do Offerors Provide Any Cost Input?			
	Yes		No	
	Responses	Percentage of "Yes" Response	Responses	Percentage of "No" Response
0 - 10	3	16.7	4	14.8
10 - 20	9	50.0	6	22.2
20 - 30	4	22.2	7	25.9
30 - 40	1	5.6	-	-
40 - 50	-	-	-	-
50 or more	-	-	4	14.8
No Factor	1	5.6	6	22.2
TOTAL	18	100.1%*	27	99.9%*

*Error due to rounding.

of the "no" responses. In addition, approximately 15% of the "no" group reported variances of 50% or greater. Those project managers who received cost inputs from offerors did not report variances greater than the 30-40% range. Based on this limited data, it appears that discussions with potential bidders concerning costs, assists the project managers in estimating costs more accurately. Again, this area requires additional research coupled with verified variance data before a firm conclusion can be reached.

A final observation concerning the responses to Question 19 must be made at this point. Several project managers who did not discuss costs with bidders explicitly stated this practice was strictly prohibited. When queried about the source of a policy forbidding cost discussions with offerors prior to RFP issuance, they could not pinpoint a regulation or local policy. Discussions with some senior procurement personnel revealed that, in fact, there is no Air Force or DoD policy which restricts pre-RFP cost discussion with offerors. However, the senior procurement personnel stated that each laboratory has its own unwritten policy which most project managers adhere to. While the researcher did not verify the nonexistence of Air Force or DoD policy, it appears there is considerable confusion concerning the proper procedures to follow, and this issue should be clarified. If open pre-RFP discussions with potential offerors help to reduce the magnitude of variance then, in the long

run, the decreased variance should provide laboratory management with increased confidence in their budget planning.

The final discussion which focuses on cost estimating accuracy involves Question 6 and again Question 25. The combination of these two questions addressed Research Question 2: Is there a relationship between cost estimating accuracy and the type of work unit performed? In the two previous sections it was reported that the majority of project managers interviewed had managed combinations of studies, hardware, and test projects and very few managed work units of strictly one type. As a result, no conclusions or even trends can be derived from the data presented in Table 3-13. While twelve of the fourteen project managers reported variances of less than 30% for all three types of work units, the data is insufficient for a trend to be established. Since most project managers seem to manage combinations of studies, hardware, or test projects additional research which tries to identify accuracy as a function of work unit type may not be possible.

The previous discussions in this section concentrated on identifying relationships between estimate accuracy and various aspects of laboratory project management. The remainder of this section will discuss the factors resulting in inaccurate estimates from the project manager's perspective.

The responses to Question 25 clearly revealed the difficulty project managers have in accurately estimating

Table 3-13: Accuracy as a Function of the Type of Work Unit (Studies, Hardware, or Test)

Variance (%)	Type of Work Unit					
	Studies		Hardware		Test	
	Responses	Percentage of "Studies" Responses	Responses	Percentage of "Hardware" Responses	Responses	Percentage of "Test" Responses
0 - 10	3	42.9	1	25.0	-	-
10 - 20	-	-	2	50.0	2	66.7
20 - 30	2	28.6	1	25.0	1	33.3
30 - 40	-	-	-	-	-	-
40 - 50	-	-	-	-	-	-
50 or more	-	-	-	-	-	-
No Factor	2	28.6	-	-	-	-
TOTAL	7	100.1%*	4	100.0%	3	100.0%

*Error due to rounding.

costs for a new project. Some project managers seem to have less difficulty than others but almost all miss the mark by some degree. From the summarized responses in Appendix C, at least 16 respondents indicated they generally under or overestimate by 25% or more. One respondent even indicated he had underestimated by 200%. Only one project manager said the variance was "surprisingly little" and was not concerned about any variance that occurs. Due to the high occurance of inaccurate estimating and the level of concern registered by the respondents, the responses to Question 26 were considered to be of significant importance. If the source of the variance can be identified then perhaps some action can be taken to rectify the problems.

The summarized responses to Question 26 in Appendix C lists 14 different factors that project managers attributed to the variance between their estimate and the bidder's proposed costs. However, the factors can be classified into two major categories as shown in Table 3-14. The categories are:

1. Variance due to inaccurate estimating by the project managers.

2. Variance due to estimating errors by potential offerors.

Because of the importance attached to identifying the variance factors, each category is discussed in more detail.

The major variance factor attributable to the project managers was inaccurate estimating of manhours or

Table 3-14: Factors Contributing to Cost Variance

Factors	Responses	Percentage of Total Responses (%)
INACCURATE ESTIMATING BY PROJECT MANAGER	35	62.5
ESTIMATING ERRORS BY POTENTIAL OFFERORS	18	32.1
OTHER FACTORS	3	5.4
TOTAL	56	100.0%

labor rates, closely followed by the second major factor, inaccurate estimating of overhead rates. These two factors received ten and nine responses, respectively. The emphasis they received is logical since labor and overhead were the major cost drivers identified previously. Some interviewees elaborated on the reasons for the inaccurate estimates. One project manager said the time lag between issuance of the RFP and contract award can exceed nine months. During that period of time the rates, including labor and overhead, may change for a particular company resulting in a cost variance. Another respondent felt the government estimates were "looser" than industry estimates because contractors have the inside knowledge required to estimate the manpower needed to perform a task. However, one project manager had an opposing viewpoint. He felt project managers in his laboratory estimated labor to a relatively high degree of accuracy but contract costs were still sometimes significantly higher than estimates made by the project managers. He attributed this anomaly to the fact that some companies may be located in a high cost area and have substantially higher labor and/or overhead rates. Finally, one individual indicated overhead rates are highly dynamic and increase drastically from year to year. Interestingly, when his reponses to Questions 12 and 13 were checked, it was noted he relied on past projects as his source of overhead rates. Had he used the current rates available through his local financial

analysis office, his overhead cost estimates could have been more realistic.

Use of an optimistic inflation rate by the government was another major factor attributed to the cost variance. Several project managers said they were instructed by the local financial analysis office to use an annual inflation rate of 6% or less when the actual rate was as high as 12%. As a result, the bidder's proposed costs were higher than the government's estimate. Verification of inflation rates was not within the scope of this effort, but laboratory management should consider additional investigation of this issue.

Other cost items which were incorrectly estimated by the project managers included materials, hardware, subcontracting costs, fee, fringe benefits, and management reserve. In addition, two respondents said they were forced into making low estimates because of limited funds available for the work unit. In other words, the estimate was made on the basis of funds available rather than a realistic estimation of the resources required to conduct the effort. Because of the limited number of responses for any one of these items, it will be assumed that they are not major variance factors and will not be discussed further.

The major variance factor attributable to the bidders was errors in estimating as a result of misinterpretation of the Statement of Work (SOW). This factor received a total of ten responses under Question 26. Since several

test respondents identified misinterpretation of the SOW as a variance factor, it was decided this area justified further scrutiny. As a result, Question 27 was added to the finalized version of the interview. The responses to Question 27 in Appendix C clearly show that variance is due, in part, to misunderstanding of the SOW. More than 75% of the project managers gave a positive response to this question. While some of the responsibility for misinterpretation goes to the potential offerors, the majority falls on the shoulders of the project manager. If the objectives and performance requirements of the work unit are not complete and clearly written, then misinterpretation will result (4:p 3-1). Writing a complete and clear SOW is not an easy task. The SOW should be definitive enough to protect the government's interest and yet broad enough to allow for the contractor's creative effort to be added to the program. Therefore, if the variance between the bidder's estimate and the contractors proposed costs is to be minimized, it appears more complete and definitive SOWs are required.

[illegible] des misinterpretation of the SOW, the respondents also indicated that offerors sometimes propose a different level of effort than specified in the SOW due to technical insight known only to the offeror. An example would be Independent Research and Development (IR&D) conducted by the contractor prior to RFP issuance. As a result of the offeror's additional knowledge, a variance occurs.

Three respondents also indicated some offerors propose to conduct the effort at an unreasonably low cost in order to win the contract. This practice, known as "buying-in", is discussed in more detail later (See discussion of Question 29).

The final two variance factors attributed to the offeror's were:

1. The offeror decides to perform additional work not specified in the SOW or proposes a "glamorous" program.

2. The offeror is unfamiliar with government contracts, and as a result, misinterprets what is required (similar to misinterpretation of SOW).

These factors are self-explanatory and will not be discussed further.

Once the various causes or factors contributing to the difference between a project manager's estimate and the bidder's costs were identified, the research focused on establishing whether project managers attempt to determine where the cost differences exist. If past variances are identified then the knowledge should help to reduce future variances. The responses to Question 28 in Appendix C indicate the majority of project managers do try to determine where the variance occurs. Thirty-two respondents said they compared their estimate with the bidder's, in considerable detail, and discussed the differences during negotiations. Some project managers even compared costs at the second level

of the Work Breakdown Structure (WBS). Seven respondents said they made some attempt to determine where the variance occured but not in a detailed manner. Three project managers made an effort if the cost differential was of such a magnitude that the project could not be funded. Only a small percentage (6.7%) did not make any attempt to establish the reasons for the variance. While it appears that most project managers assume the responsibility of identifying the reasons for cost differences, the results did not provide data on whether this information assists in decreasing the variance on future work units. This is another area in the cost estimating process that requires further study.

The practice of identifying differences between cost estimates made by the project managers and offerors can be considered a method to reduce the magnitude of variance on new work units. Other methods would be to conservatively estimate (on the high side) labor, overhead, materials, etc., while performing the estimate, or to add a contingency factor to some cost items or the overall cost. The results from Question 32 provide data on the methods used by project managers to cope with the uncertainties in the cost estimating process. The responses in Appendix C reveal that at least half the project managers use some type of contingency factor, inflation factor, or management reserve. Another 20% estimated costs conservatively throughout the estimate. Only a small percentage relied on their experience to deal with the uncertainties. The remaining ten respondents did not rely

on any particular method and generally estimated as realistically as possible. Sixteen project managers gave specific contingency/inflation/management reserve factors presented in Table 3-15. The majority used factors within the range of 5-30%, however, two used very high factors - up to 300%. Interestingly, both respondents who used the high factors indicated the offeror's costs were generally 25-30% higher than their estimates. The results indicate most project managers compensate for the uncertainties in their estimate in some fashion, and also serve to support the assumption that cost estimating within Air Force laboratories is an ambiguous process.

The final question addressed in this section sought to determine if project managers compare their original estimate or the offeror's estimate with the actual costs of the project. The comparison could help to identify variance factors which, in turn, could reduce the variance on future efforts. In Chapter 2 it was suggested that Question 29 could also provide information concerning the practice of "buying-in" by contractors. The results reveal that approximately 58% of the interviewees did not make the comparison between the two estimates. Of the sixteen respondents who did compare the estimates only five indicated the comparison was made routinely and was beneficial. Therefore, the majority did not see any significant benefit in making such a comparison.

Table 3-15: Contingency Factors, Inflation Factors, or Management Reserve Used in Cost Estimates

Contingency Factor, Inflation Factor, Management Reserve (%)	Responses
5 - 10	1
10	4
10 - 15	4
15	1
10 - 20	2
25	1
30	1
100 - 200	1
200 - 300	1
TOTAL	16

Many respondents stated that since costs were being tracked continously during the life of the project, a cost comparison between the original estimate and final costs served no useful purpose. Additionally, only two project managers were able to see how the comparison related to the "buying-in" process. Thus, the responses to Question 29 indicated the following:

1. Most project managers do not compare their original estimate or the contractor's original estimate with final contract costs.

2. Most project managers see little benefit in making such a comparison.

3. Information concerning the "buying-in" process could not be obtained.

Although the results are contrary to the assumption that a comparison of original estimates versus final costs are beneficial, the author is still of the opinion that useful information could be obtained from such a comparison. If time had permitted a full explanation of the rationale behind Question 29 to each interviewee, the results may have been significantly different. This is another area where further research is required.

This section focused on identifying the major factors contributing to the variance between the project manager's estimate of costs for new work units and the costs proposed by the offerors. Numerous ancillary issues relating

to cost estimating accuracy and difficulty were also addressed including four research questions. With this knowledge of cost estimating techniques employed and identification of variance factors, the weakness in the current cost estimating process and suggestions for improvement will be discussed in the following section.

Limitations, Weaknesses, and Recommendations for Improvement

One of the major objectives of this research effort was to indentify weakness in the cost estimating process as seen through the eyes of the laboratory project managers. Question 34 provided the project managers the opportunity to express their perceptions of these limitations/ weaknesses. However, there are five ancillary issues perceived as potential weakness that will be discussed first. These issues were identified through the test interviews and during the author's years as a laboratory project manager.

Failure to retain the original cost estimate is the first weakness to be discussed. In Chapter 2 three benefits for retaining the initial estimate were listed:

1. The old estimate could help in estimating costs for new work units of a similar nature.

2. The estimates could serve as a baseline for evaluating an offeror's proposal.

3. Retention of the estimate is mandated by Air Force Systems Command (1:1, 7:1, 9:1, 10:1).

Therefore, retention of the original estimate would not only be a useful management tool, but would also eliminate the identification of a discrepancy during a formal inspection from higher authorities. (In the Air Force this type of inspection is refered to as an Inspector General or IG inspection). The summarized responses to Question 24 in Appendix C reveal that approximately 35% of the respondents did not retain their initial estimate. Many of the respondents, including those who retained their estimates, were not even aware that retention was mandatory. Some also stated they discarded the estimate after contract award. These results are considered one of the significant findings of this study because more than a third of the project managers dispose of useful information which could assist them in estimating future costs. Laboratory management or the office of the Director of Laboratories should consider further exploration of this issue to ascertain the impact of these findings.

In Chapter 2 a detailed discussion of the Job Order Cost Accounting System (JOCAS) was presented. To reiterate, AFSCP 177-3 [3:2] specifies the purpose of JOCAS is to:

> ..... identify the total cost of specific efforts and organizations and create a cost consciousness in the R&D manager. Once identified, the cost information has numerous uses including assisting the manager to budget, allocate, recoup, and analyze his initial financial resources.

AFSCM 177-265 [5:2] also states the information provided

by the JOCAS must be used:

> ..... to support job estimating and reimbursement billings and can be used to measure productivity, develop performance and cost standards and to determine where management emphasis should be directed.

A final requirement specificied in AFSCM 177-265 [5:11] which was not discussed in Chapter 2 is that:

> The financial reports produced by the cost accounting system must meet the test of usefulness to the officials requiring the data in the proper discharge of their management responsibilities.

The author is of the opinion that the monthly JOCAS information provided to project managers is not useful for estimating costs for contractual work units. The data, in the form of a computer printout, does not break out costs in a manner that would be useful for future estimating purposes. Instead, the data provides only cumulative current fiscal year costs for the project and normally lags the contractor's reports by a month. Thus, the information is insufficient and is not timely. Questions 21 and 22 were designed to support the author's opinion. Question 21 asked the project managers if they receive JOCAS reports. Since JOCAS was mandated by Headquarters Air Force, it is not surprising that over 95% of the respondents indicated they did receive JOCAS information. However, when asked if they used the information to assist in estimating new contractual efforts, 89% said they did not use it for that purpose. Some project managers provided the following reasons for not using JOCAS:

1. JOCAS is not reliable.

2. JOCAS does not provide sufficient detailed information.

3. JOCAS information is months behind the financial reports received from the contractors.

Thus, there was almost universal agreement among the interviewees that JOCAS lacked cost estimating utility. If JOCAS is underutilized to the same extent throughout the Air Force laboratories then management should reevaluate the system's usefulness.

Question 30 sought to establish the adequacy of information and/or tools available to project managers to estimate labor and costs. The summarized responses in Appendix C indicate more than 25 of the respondents felt they had adequate information and/or tools while 12 were not satisfied. Seven project managers were not completely content with the tools or information at their disposal and one respondent was uncertain.

Numerous project managers provided additional information to Question 30 which should be reported. Several respondents felt a deficiency of tools or information, but because they did not know what was available, could not suggest anything. One project manager said a computer program that would help in estimating costs accurately would be desirable, but was not convinced the cost or time expended would be worth the effort. Another project manager also said a computer program would be beneficial but suggested it be simple to use or else it would not be utilized. Finally,

several interviewees felt they had sufficient tools because of their experience, however, for the inexperienced project manager they felt tools were definitely lacking. In summary, more than half of the respondents revealed they had sufficient information and/or tools to accurately estimate costs. However, some qualified their "yes" responses with comments indicating that certain additional tools and/or information would be beneficial. Thus, there appears to be considerable room for improvement in this area.

Question 31 was added to the interview to determine if project managers had sufficient time to satisfactorily complete their cost estimates. The results in Appendix C indicate lack of time was not a problem. Eighty percent of the respondents said they had adequate time and only 16% gave a negative response. The remaining two project managers said the lack of time was an occasional problem.

Several project managers also elaborated in their responses to Question 31, and their comments are worth noting as they provide interesting contrasts in cost estimating philosophy. One project manager said time was generally adequate if the work unit involved a familiar technical area. However, if the project involved a new technical area which lacked historical data, then time was inadequate because facts had to be gathered from other sources. Another project manager indicated the new formalized cost procedures require considerably more time than when costs were estimated strictly on historical data and experience. This individual also

commented that the new procedures were not as beneficial as thought to be by management. Still another respondent revealed that because the estimating process is not formalized, little time or effort was put into making the estimate. Finally, one project manager said the time required to perform an estimate was not worth the effort because only a certain amount of funds were available to perform the project. As a result, the estimate is made in reverse; from a final dollar value to specific costs rather than the specific costs cumulating to a final dollar amount. It did not matter if a realistic estimate far exceeded the funds available; no additional funds would be provided.

To conclude this discussion of Question 31, insufficient time does not appear to be a critical factor in the estimating process. However, some situations were reported in which time was at a premium. In light of some comments made concerning the emphasis placed on availability of funds rather than the accuracy of the estimate, a recommendation for additional research is made: The research should involve interviewing laboratory management to determine what their uses and perceptions of the value of the cost estimates are.

In Chapter 2 the rationale for Question 33 was discussed in detail. A planning cycle scenario was presented and two assumptions concerning the original cost estimate made:

1. The original estimates are made hastily due to the time pressure of the planning period. As a result, these estimates may differ significantly from the estimate made during RFP preparation.

2. When the project is funded, perhaps several years later, the project managers are forced to abide by the original estimates. Question 33 was incorporated in the interview to determine if the circumstances described by the assumptions occur and whether project managers consider these occurances to be a problem. The responses, presented in Appendix C, were classified under one of four categories: Very constrained, moderately constrained, somewhat or not very constrained, and not constrained at all.

The tabulated responses and additional comments provided by the project managers do not support the initial part of the first assumption that the estimates are made in haste. Only one project manager said his planning cycle estimates were made hastily. However, the responses and additional comments do substantiate the second assumption and part of the first assumption that a variance often exists between the planning estimate and the pre-RFP estimate. More than 50% of the respondents indicated they were very or moderately constrained by the cost estimates made during the planning cycle. Therefore, the results seem to indicate that a problem exists in this area of planning cycle estimating.

Numerous project managers who felt constrained by the initial estimates provided several consequences which may be thought of as methods to compensate for underestimating:

1. The scope of the effort is reduced. (7 responses).

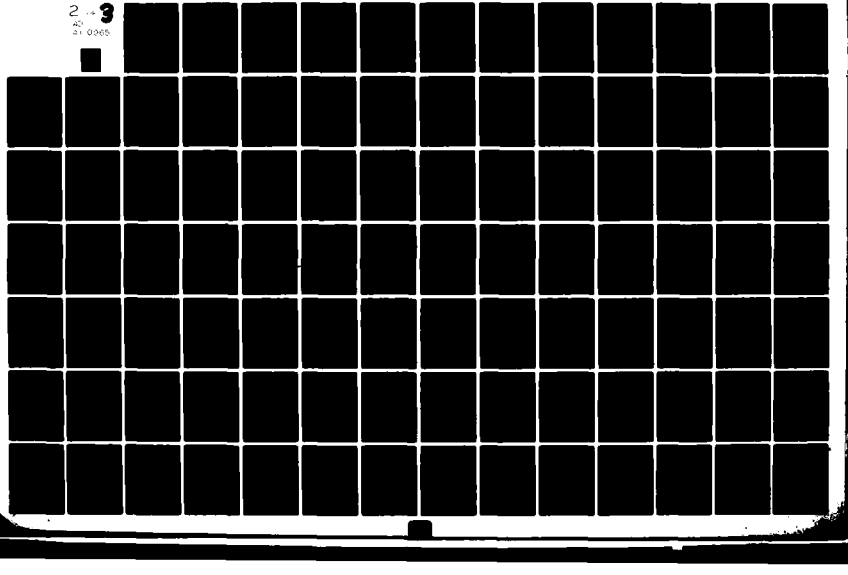
2. The project is stretched in duration so outyear dollars can be used to fund that portion of the project which could not be funded in the current fiscal year. (2 responses) This consequence resulted in the third situation.

3. New projects slated to begin in the outyears are deleted. (2 responses)

4. Planning estimates are always inflated to avoid underestimating. (2 responses)

While these methods are no doubt effective, numerous theoretical side effects which can be detrimental to the project itself or future projects can be identified. First of all, if the project is descoped the technical aspects of the project may suffer and the results or end products may be less than desirable, relative to original expectations. Consequently, a work unit costing hundreds of thousands of dollars may fall far short of its technical objectives because key technical work was deleted. This is not to say that all R&D efforts which have not been reduced in scope will always achieve their technical goals. However, deletion of key technical work in a well planned project must increase the probability of not achieving the technical goals.

AD-A110 965 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 15/5
AN ANALYSIS OF THE COST ESTIMATING PROCESS IN AIR FORCE RESEARC--ETC(U)
SEP 81 H W SCHEEL
UNCLASSIFIED AFIT-LSSR-82-81 NL



If a project is stretched in duration all technical objectives may be realized but the total dollar value of the project may increase. The increase is a result of overhead costs charged to the project for the months or years the project was extended. In addition, the effects of inflation and rate increases may also take their toll. If the project is funded in the outyears, new projects planned for future years may be eliminated. Innovative projects which, in the long run, could result in technological breakthroughs, may never see fruition if funds are cut. Inflating estimates during the planning period could also preclude funding of projects. Laboratory management may decide the project is too expensive to fund or may elect to delete another project in order to fund the work unit with the inflated estimate. Further research is required to identify the causes of low planning estimates. If causes are identified and solutions applied which reduce the variance, the use of the four methods to compensate for underestimating may also be reduced or even eliminated.

Finally, a comment made by some respondents who said they were not constrained by planning estimates is worth a brief discussion. Eight project managers indicated that while planning estimates were not a constraint, the laboratory or division budget was a definite constraint. If the current fiscal year budget did not have sufficient monies to fund the entire project, some method to reduce the current year dollar requirement was initiated. It was of little consequence

that the planning cycle estimate was identical to the offeror's proposed costs. The four consequences discussed in the two previous paragraphs were also the ones identified by these eight respondents. Thus, the planning estimate and the current budget both appear to be major constraints imposed on the project managers interviewed.

The previous paragraphs addressed certain issues of the estimating process which the author thought were limitations or problems. The final two questions discussed in Chapter 2 are also concerned with weaknesses and/or problems of the cost estimating process but from the project manager's viewpoint. Question 34 provided the respondents with the opportunity to state their perceptions of the limitations, weaknesses, or problems of the laboratory cost estimating process. Then Question 35 asked the respondents to suggest constructive recommendations for improvement. Rather than discussing Questions 34 and 35 separately, the recommendations for improvement will be addressed immediately following the discussion of the problem.

The responses to Question 34 are listed in Appendix C. As one can see, the variety of problems were numerous and only 13 individuals (28.9%) said they were not aware of any problems. There were six more responses than project managers interviewed because some respondents identified more than one weakness. In those instances, each weakness received one response. Since the problems were so numerous

only those limitations which received the higher percentage of responses will be discussed.

The lack of tools, models, guidance, or training to assist the project managers in making their estimates was the problem which received the most responses. (This problem was previously addressed in the discussion of Question 30). The majority of the recommendations to improve the situation involved some type of computer program or data base. Several project managers suggested the data bank contain certain manhours, rates, etc., for various work units. The work units would be classified by their distinguishing characteristics, and the manhours and rates could then be retrieved on the basis of those characteristics. One respondent suggested having the rates and manhours published in a standardized format in the final report of the contract. This would simplify inputting the raw data into the computer. Some project managers also felt the system should be simple, quick in information retrieval, and kept up-to-date. Finally, one respondent suggested a cost estimating guide be established for inexperienced project managers. The respondent indicated several private companies currently have cost estimating guides in operation but could not identify the companies.

The limitation which received the next highest number of responses has already been addressed in the discussion of Question 33. The problem is that project managers are forced to comply with their original planning cycle estimate. The recommendations to improve or correct

this problem were very limited. One individual said more time should be made available during the planning cycle in order to estimate the costs in greater detail. Another recommendation was to decrease the acquisition lead time. It was pointed out in Chapter 2 that several years may elapse between the planning cycle estimate and the award of the contract. During this period of time overhead and labor rates increase and this, coupled with inflation, can significantly drive up the costs. If the lead time is decreased, this should in turn decrease the cost growth resulting from outside factors. The final recommendation is complete in itself and requires no further explanation. The suggestion was to provide project managers with the flexibility to update their initial planning estimates.

The problem identified in responses c. and k. of Question 34 in Appendix C are related problems and are discussed together. Four respondents indicated they did not have the technical or cost insight that industry has, consequently, they cannot estimate costs as accurately as the offerors can. This limitation, in turn, leads to the problem of policies which restrict pre-RFP technical or cost discussions with potential offerors. Of course, the solution proposed by most of the respondents was to permit open discussions with contractors in terms of technology and resources. The respondents felt these discussions would decrease the variance between their estimate and the offeror's proposed costs. Recalling from the discussion of Question

19 in the previous section, the results indicated that project managers who received cost or manpower estimates from potential offerors also had lower reported variance than those project managers who did not receive cost or manpower inputs. One respondent, however, did not feel interface with potential offerors was necessary because the offerors also tend to be optimistic in their estimates.

The problem concerning budgetary constraints (response j. of Question 34) has already been discussed but the recommended solution has not. The respondents suggested the government inform the offerors of the work unit's technical objectives and the dollars available. The offerors would then formally tell the laboratory how much they could accomplish with the funds available and justify their proposed technical efforts and resource expenditures. The laboratory would then evaluate the proposals and select a single contractor on the basis of the soundness of the contractor's plan. This suggestion was classified under the e. responses of Question 35; reduce the restrictions which prohibit discussions between project managers and potential offerors.

Several project managers considered the lack of experience of novice project managers or the loss of experience due to a high turnover rate to be problems. With the present high influx of individuals without any prior R&D or management experience into the Air Force laboratories, this lack of experience could become acute. Therefore, it was

surprising that more respondents did not identify this as a serious problem. The respondents recommended a computer data bank, formal guidelines, and formal training as methods to assist or educate the novice. (These methods have already been discussed.) However, this study has shown that these methods are not available. The only other suggestion provided by the respondents was that cost estimates made by inexperienced project managers should undergo close scrutiny by supervisors or experienced project managers.

The remaining limitations/weaknesses which are summarized in Appendix C, are self-explanatory and will not be discussed further. However, there are several suggestions for improvement which were not aimed at any particular problem but which deserve elaboration. The solutions all called for the cost estimate to be a combined effort of experts or to have some other individual/organization perform the estimate. Several individuals suggested a large staff of experienced people or a team of individuals of various technical disciplines perform the estimate. As a result, the project manager would not have to make a "seat-of-the-pants" estimate in an unfamiliar technical area. Another project manager suggested a cost analyst/estimator be assigned at the project level. However, the individual was quick to add that this action could be prohibitive due to the cost involved and shortage of personnel. (During the course of the interviews the author identified several laboratories that had a cost analyst/estimator at the division level). Finally, one astute

project manager was not able to provide a suggestion for improving the cost estimating process but did make an interesting observation. He said the majority of project managers in Air Force laboratories have backgrounds which are tehcnical in nature, and yet laboratory management expects them to perform financial analysis which is a discipline they are not trained in. Thus, he felt it was "somewhat unrealistic" for management to expect project managers to accurately estimate costs.

This section discussed numerous weakness, limitations, and/or problems in the current laboratory cost estimating process as identified by the project managers interviewed. The variety of responses were extensive, thus, only the major problems were addressed. After each problem identification the suggestions provided by the respondents to improve the situation were also presented. In addition, five issues perceived as potential problem areas by the author were also discussed.

Summary

This chapter discussed the responses to each of the 35 interview questions and analyzed the results. The first section focused on the demographic questions which identified grade/rank, experience level, type of work unit managed, and dollar value of contracts. In the following section the responses to the various questions regarding cost estimating methodology and techniques were discussed. In addition, the

responses which addressed the single hypothesis and one of the research questions were analyzed. The third section investigated the remaining four research questions and several ancillary cost variance questions. The final section discussed the limitations and weaknesses of the laboratory cost estimating process and presented the recommendations for improvement.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the major conclusions drawn from this research effort and based upon those conclusions, recommendations for improving the laboratory cost estimating process. The conclusions and recommendations will be grouped into three major sections:

1. Cost estimating methods and techniques.
2. Factors contributing to cost estimating accuracy.
3. Miscellaneous conclusions and recommendations.

The recommendations, whether based on the researcher's own opinion or the opinion of the interviewees, will immediately follow each conclusion.

Cost Estimating Methods and Techniques

The primary conclusion drawn from this study concerning cost estimating methodology in Air Force laboratories is that limited cost estimating guidance is available. Project managers rely almost exclusively on historical data from past work units or recent cost proposals and/or their own project management experience accumulated over the years. Reliance on historical data and/or experience did not apply to general cost estimates alone, but to all subestimates as well. Cost estimates made for manpower, materials, tooling

and special equipment, computer time, and travel were all based on experience and/or historical data. In addition, historical data is the primary source of the overhead rates, labor rates, and general and administrative (G&A) rates. Although all project managers had access to a financial analysis office or a local procurement organization which could provide up-to-date rate information, only one-third of the interviewees utilized these sources.

The study did not, however, clearly establish whether the lack of cost estimating guidance is detrimental or beneficial. Neither did the study show that formal guidelines would reduce the 30% or less variance reported by the majority of the project managers interviewed. Many of the experienced project managers were completely satisfied relying on their own experience or historical data to estimate costs. But at least 27% were not satisfied and indicated cost estimating information and/or tools were inadequate. Some project managers were also concerned with the low experience level of novice project managers and the loss of experience due to a high turnover rate. Thus, estimating costs strictly on the basis of experience and/or historical data appears to be more than adequate for many project managers, but some desire to have more definitive guidance to assist them in increasing the estimate accuracy or to assist the inexperienced project managers.

Most project managers desiring cost estimating guidance recommended some type of computer program or data

bank containing current manhours, rates, etc. for various work units. The work units would be classified by their distinguishing characteristics, and the manhours and rates could be retrieved on the basis of those characteristics. Of course, the structure of the data base must relate to cost reporting requirements, such as manhours and rates for various education and/or experience level of project personnel, material costs, overhead rates, and subcontracting costs. It was also recommended that the system be simple, quick in information retrieval, and kept up-to-date. A final recommendation concerning a computerized system is that the software be standardized throughout the Air Force laboratories. A standardized system would minimize the familiarization time for personnel being reassigned from one laboratory to another.

While a data bank would provide very useful information, the inexperienced project manager would still need guidance in the application of this information. This guidance could take the form of local guidelines and/or a formalized course through the Air Force Institute of Technology. This research effort has shown that experienced project managers generally do not have a specific method to estimate costs, thus, it would be difficult if not impossible to instruct the new project managers in a particular technique. However, the guidelines or formal course should provide instruction on the various cost items to consider, the source of rate information (labor, overhead, G&A,

computer hours, etc.), vendor's catalogs available, and perhaps a listing of experienced project managers in a variety of technical disciplines that could assist in preparing the estimate. Obviously, the inexperienced project manager will not be able to perform an accurate cost estimate based solely on this information. Experience will be the best available tool and they should be encouraged to rely on guidance from senior project managers or supervisors. However, the guidelines should at least provide the novice with a working knowledge of the laboratory cost estimating process that, in turn, will help to reduce the time required to become "experienced."

This research effort focused primarily on experienced project managers to determine cost estimating techniques because of the assumption that inexperienced project managers could provide only limited information in this area. In an indirect manner the results of this study support that assumption. If the experienced laboratory managers were not able to provide specific methodologies, other than experience and/or use of historical data, it is doubtful whether inexperienced project managers could have provided additional techniques. On the other hand, relatively inexperienced project managers could provide very valuable insight on the type of information which would benefit them in performing their cost estimate. As an example, a project manager with one year of experience and having agonized through one or two cost estimate should be in an excellent position to

identify deficiencies in the current system and suggest improvements. Therefore, this author recommends a study, similar to this research effort, be conducted which focuses on the novice laboratory manager. The results of such a study should direct laboratory management to the critical areas where additional guidance/information is required.

In this section the conclusions that cost estimating techniques are very limited in Air Force laboratories was discussed and numerous suggestions to improve the level of guidance, especially for inexperienced project managers, were presented. This research effort also sought to identify the factors which contribute to the variance between the project manager's estimate and the costs proposed by potential offerors. In the following section, the conclusions concerning cost estimating variance will be presented and recommendations to decrease the variance will be discussed.

Factors Contributing to Cost Estimating Accuracy

In Chapter 3 accuracy was defined as the difference in costs between the project manager's estimate of costs and the costs proposed by potential offerors. This discrepancy was refered to as "variance." It was also pointed out that because Question 25 (the vehicle used to identify the variance) was based on "best guess" responses, firm conclusions could not be made. This caveat is again reiterated at this point. Many of the accuracy conclusions discussed

in this section are based on the unvalidated responses to Question 25. Therefore, caution should be exercised if laboratory management decides to initiate corrective action on the basis of these conclusions concerning estimate accuracy. Additional research may be required to fully substantiate the variance reported in this study.

A very obvious conclusion, and one which most project managers as well as laboratory management are acutely aware of, is that most project managers do not accurately estimate costs for new projects. The majority underestimate by 30% or less, with some underestimating by as much as 200%. The project managers attributed the following as the major factors which contribute to inaccurate estimates:

1. Laboratory project managers inaccurately estimate manpower (both manhours and manhour rates).

2. Laboratory project managers inaccurately estimate overhead rates.

3. Laboratory project managers are required to use optimistic inflation factors.

4. Potential offerors misinterpret the Statement of Work (SOW).

A method to reduce the manpower variance has already been discussed in the previous section. A computerized data bank which contains the manhours/manyears to perform similar efforts should assist project managers, especially the inexperienced, in accurately estimating manpower requirements.

In order to increase the accuracy of the manhours or overhead rates, project managers should utilize local sources which provide current rate information. Each laboratory participating in this study had either a financial analysis office or a procurement office which provided various types of rate data, yet only one-third of the project managers made use of this information. This study did not reveal the nature of the nonutilization but several causes can be postulated:

1. Project managers are not aware the rate information exists.

2. Project managers simply elect not to use the information.

If the first situation exists then laboratory management should actively publicize the availability of the information. If the second situation exists then the finanical analysis or procurement offices should insure the information is easily accessible, readily understandable, and kept as up-to-date as possible to encourage its use.

This study did not validate the complaint that project managers are required to use optimistic inflation factors. If in fact, some managers are required to use inflation factors as low as 6% then some effort should be made to establish a more realistic rate. In any case, additional research in this area is required.

The responsiblity of reducing variance due to misinterpretation of the SOW falls clearly with the project

manager and laboratory management. The objectives and performance requirements of the work unit should be complete and clearly written. The project manager should insure the SOW is definitive enough to protect the government's interest and yet broad enough to allow for the offeror's creativity to be added in the program. Thus, laboratory management should provide project managers with the guidance and instructions required to insure complete and clear SOWs.

Three additional factors appear to affect cost estimating accuracy:

1. Detailed cost estimates decrease the overall accuracy of the estimate.

2. Accuracy decreases as the number of potential offerors generally responding to an RFP increases.

3. Accuracy increases as the level of pre-RFP cost discussions with potential offerors increase.

As stated at the beginning of this section, these conclusions are based on unvalidated variance responses. Additional research is required before these conclusions can be established as concrete. Therefore, no recommendations will be made with the exception of the third factor.

The limited results of Questions 19 and 25 seem to indicate cost discussions with potential offerors assist the project managers in estimating costs more accurately. In addition, some project managers identified the restrictions limiting pre-RFP cost discussions with potential offerors as a significant weakness in the laboratory cost estimating

process. Others, while not specifically identifying the restrictions as a problem, said offerors are generally aware of the funds available. Consequently, the restrictions are of little value. While there is insufficient evidence to warrant a complete lifting of the restrictions, some action in this area is required. The researcher suggests a limited study of selected work units in which pre-RFP cost discussions are permitted. Offerors would be informed of the funds available and the technical objectives. The offerors would then formally tell the laboratory how much they could accomplish with the funds and justify their proposed technical efforts and resource expenditures. The laboratory would, in turn, evaluate the proposals on the basis of the soundness of the offeror's plan. The success of these projects in terms of cost overruns, scope reductions, and technical objectives achieved would then be compared with similar projects not engaged in pre-RFP cost discussions.

Miscellaneous Conclusions and Recommenations

The previous section presented a wide variety of conclusions regarding the factors or causes which contribute to the variance between cost estimates. In this final section some miscellaneous cost estimating conclusions drawn from this study are discussed and recommendations presented.

The first conclusion is that many project managers do not retain their original cost estimate. The recommendation is to retain this estimate and for the following reasons:

1. The old estimate could help in estimating costs for new work units of a similar nature.

2. The estimates could serve as a baseline for evaluating an offeror's proposal.

3. Since retention of the estimate is mandatory, disposal could result in an inspection discrepancy.

Another conclusion is that the Job Order Cost Accounting System (JOCAS) is not a useful cost estimating tool. The research identified three reasons for the non-utilization of JOCAS by project managers:

1. JOCAS is unreliable.

2. JOCAS does not provide sufficient detailed information.

3. JOCAS information is months behind the financial reports received from the contractors.

Based on this conclusion at least two options are available:

1. Update the system to provide practical information in a timely fashion.

2. Eliminate the JOCAS reports entirely (if they serve no other management functions).

The second option could probably save the Air Force thousands of dollars a month in computer paper and computer usage, as

well as dollar savings resulting from less manpower expended to process, distribute, and file the JOCAS reports.

The study also revealed that managers felt constrained by the initial cost estimate made during the planning cycle, or were constrained by the laboratory or division budget. These constraints result in the following consequences:

1. The scope of the effort is reduced. As a result, the technical objectives of the work unit may suffer.

2. The project is stretched in duration. As a result, the total dollar value of the project may increase and new projects planned for the outyears may be deleted.

3. Planning estimates are always inflated to avoid an underestimation of costs.

In light of these conclusions and their consequences the project managers proposed three recommendations:

1. Provide sufficient time during the planning cycle to realistically estimate costs.

2. Decrease the acquisition lead time to reduce the effects of inflation and rate increases which occur in the interim.

3. Provide project managers with the flexibility to update their initial estimates.

The final three conclusions are not of major importance but are presented for information purposes. No recommendations are deemed necessary. The conclusions are:

1. Manpower is the primary cost driver in most laboratory work units.

2. Most laboratory project managers have sufficient time to estimate costs.

3. Most project managers add a contingency factor or management reserve to their estimates to compensate for the uncertainties in the estimating process.

As a final comment, it should be stressed that considerable research in the area of laboratory cost estimating is still required. To reiterate what was said in the Limitations section of Chapter 2, the objective of this study was not to solve all the problems of the cost estimating process. This thesis effort was conceived as an initial investigation that would pave the way for a series of follow-on research efforts. However, the author is of the opinion that some very important information concerning the cost estimating methodology, factors contributing to cost estimating accuracy, and limitations of the cost estimating process has been uncovered through this effort. With the high influx of inexperienced project managers into the Air Force laboratories some change must be implemented. Some of the recommendations made in this chapter require little effort, such as publicizing the availability of up-to-date rate information. Other recommendations would require considerably more time to implement, such as establishing a computerized data base of completed projects and/or cost proposals. If some recommendations are implemented and

help to reduce the magnitude of cost estimating variance then, in the long run, the decreased variance should provide the laboratory management with the capability to budget funds realistically and with increased confidence.

APPENDIX A

Glossary of Laboratory Terms

1. Baselining.

The process of establishing a work unit foundation in terms of: the technical objectives to be achieved, the schedule to be maintained, and the resources to be expended. The baseline includes documenting the rationale of the generation of each of three baseline segments and any changes that occur during the life of the work unit (8:5).

2. Bidder.

A civilian company, corporation, or university that proposes or agrees to perform a specific technical work unit for an Air Force Systems Command (AFSC) Laboratory. Also known as "offeror" or "contractor."

3. Contract.

> An agreement in writing, binding on both parties, which specifies work to be performed and the terms and conditions covering such performance [12:p B-2].

4. Cost Estimate.

> The product of an estimating procedure which specifies the expected dollar cost to perform a stipulated task or to acquire an item. It may be stated as a single value or a range of values [28:4].

5. Independent Research and Development (IR&D)

Technical work conducted by private industry having a potential relationship to a military function or operation. The work is funded through company resources and remains independent of Air Force control. Some of the funds are reimbursable based on the quality of the effort, and its

potential relationship to a military function or operation (27:1)

6. Overrun.

Net change in contractual amount over that contemplated by the contract estimated cost without a change in scope or addition of requirements (12:p B-6).

7. Project Manager.

An individual responsible for planning, organizing, and managing the technical and financial aspects of Research and Development (R&D) work units in an Air Force Systems Command (AFSC) Laboratory. The term "Project Manager" is used in lieu of the terms "Project Engineer", "Project Officer", or "Laboratory Contract Manager."

8. Request for Proposal (RFP).

Solicitation form used in negotiated contracts to which bidders respond by submitting "proposals."

9. Research and Development Categories.

Research

> Scientific study and experimentation directed toward increasing knowledge and understanding in the physical, engineering, environmental, and biological-medical, and behavioral-social sciences directly related to explicitly stated long-term national security needs. It provides fundamental knowledge for the solution of identified military problems. It also provides part of the basis for subsequent exploratory and advanced developments in defense-related technologies and for new or improved military capabilities in all functional areas [26:2].

Under the Department of Defense (DoD) identification system, the first two digits of a "Research" program element would

be 61. Therefore, funding for research work units in AFSC are generally refered to as 6.1 dollars.

Exploratory Development

> A formal effort, ranging from fundamental applied research to sophisticated bread-boarded experiments, to solve a specific military problem. It includes studies, investigations, planning, programming, and minor development efforts. It is designed to develop and evaluate the feasibility and practicability of proposed solutions and determine their parameters. Program control of the exploratory development element is usually exercised by level of effort funding [26:2].

Funding for exploratory development work units is generally refered to as 6.2 dollars.

Advanced Development

> Projects that have moved into the development of hardware for experimental or operational test. They consist of investigative and analytical development planning efforts contributing to technology guidance [26:2].

Funding for advanced development work units in AFSC is generally refered to as 6.3 dollars.

10. Statement of Work (SOW).

That portion of a Government contract containing the requirements to be fulfilled, tasks to be performed, responsibility for accomplishment and specifications or standards to be met. The SOW is considered the most important part of the contract and must be complete, definitive, clear, priceable, and enforceable (12:pp I-56 to I-60).

11. Work Breakdown Structure (WBS).

The WBS is the division of a work task into smaller and smaller identifiable elements. The objective of such a

breakdown is to reach the point where a complex problem is broken down into tasks of such size that planning and performance evaluation are made easier. Each work package can be costed and scheduled separately, and progress can be evaluated based on accomplishment of each work package. The assignment dollar values to work packages permits schedule deviations to be quantified in cost terms. Cost deviations from the baseline can be projected as cost over/underruns by discrete elements (19:287-290).

12. Work Unit.

All work performed in the DoD falls into one of ten major programs, such as Strategic Forces, General Purpose Forces, Research and Development, etc. Each of these programs is divided into program elements which is the standard level of identification within the DoD. Under each element there are normally three levels of work. The first is the "project level," identified as either a project, a program, or a system. The next level is the "task level" or subtask. The lowest level of definable efforts is called a "work unit" (6:pp 2-1 to 2-3).

APPENDIX B

The Interview

1. Rank/Grade
2. Years of project management experience.
3. Number of contractual work units or projects for which you have estimated costs?
4. Generally, what type of projects were they - basic research, exploratory development, or advanced development?
5. What was the average dollar value of these projects?
6. Would you classify your projects as studies, hardware oriented, or test oriented?
7. How many contractors normally respond to your Requests for Proposals (RFPs)?
8. What type of method(s) do you use to estimate costs?
   a. Historical data on projects of similar scope
   b. Models (computer programs, equations, etc.)
   c. Handbooks
   d. Regulations, manuals, SOPs, etc.
   e. Other
9. How do you estimate labor?
10. Do you subdivide your labor into various education/ experience categories?
11. What is your source for the labor rates?
12. How do you estimate overhead?
13. What is your source for the overhead rates?
14. How do you estimate material costs?
15. How do you estimate tooling or special equipment costs?

16. How do you estimate travel costs?

17. How do you estimate computer costs?

18. What is your source for General & Administrative (G&A) rates?

19. Do any of the above estimates include input from potential offerors?

20. What is the main cost driver in your work units?

21. Do you receive JOCAS information periodically?

22. Do you use the JOCAS information in making your cost estimate for new contractual efforts?

23. Do you use any particular form or format, such as DD 633-4, AFWAL 28, AFFTC 296, AFWAL 95 to assist you or to record your estimate?

24. Do you retain your initial cost estimate in your work unit folder?

25. In general, by what percentage does the offeror's proposed costs differ from your estimated costs?

26. What do you feel are the primary factors that contribute to the differences between your estimate and the bidder's proposed costs?

27. Is the difference between your estimate and the offeror's proposed costs due in part to the offeror's misinterpretation of the Statement of Work (SOW)?

28. If your estimate does not agree with the offeror's estimate, do you attempt to determine why and where the differences exist? If "yes" - how? If "no" - why not?

29. At contract completion, do you compare actual costs with your original estimate and/or the contractor's original estimate?
30. Do you feel you have adequate information and/or tools at your disposal to accurately estimate labor and costs?
31. Do you feel you have sufficient time to accurately estimate costs?
32. How do you handle the uncertainties in the estimating process?
33. How constrained are you by earlier cost estimates such as those made during the planning cycle?
34. Summarize your perceptions of the weaknesses in the current cost estimating process.
35. What recommendations do you have to improve the current cost estimating system?

APPENDIX C

Summarized Responses To Interview Questions

1. Rank/Grade

RANK/GRADE	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
1ST LIEUTENANTS	4	8.9
CAPTAIN	8	17.8
MAJOR	3	6.7
TOTAL MILITARY	15	33.4
GS-12	3	6.7
GS-13	23	51.1
GS-14	4	8.9
TOTAL CIVILIAN	30	66.7%

2. Years of project management experience.

YEARS	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
< 5	11	24.4
5 - 9	5	11.1
10 - 14	4	8.9
15 - 20	20	44.4
> 20	5	11.1
TOTAL	45	99.9%*

The years of project management experience for the military respondents is as follows:

RANK	YEARS OF EXPERIENCE	RESPONSES
1LT	3	1
1LT	3.5	2
1LT	4	1
CAPT	3	2
CAPT	4	3
CAPT	8	2
CAPT	10	1
MAJ	4	1
MAJ	7	1
MAJ	10	1

1LT MEAN ($\bar{X}$) = 3.4 YEARS

CAPT MEAN ($\bar{X}$) = 5.5 YEARS

MAJ MEAN ($\bar{X}$) = 7.0 YEARS

TOTAL MILITARY MEAN = 5.3 YEARS

TOTAL CIVILIAN MEAN = 16.9 YEARS

*Percentages do not sum to 100% because of rounding.

3. During the period you served as a project manager, how many contractual work units have you estimated costs for?

NUMBER	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
< 10	16	35.6
10 - 19	9	20.0
20 - 29	10	22.2
30 - 39	4	8.9
40 - 49	2	4.4
50 or more	4	8.9
TOTAL	45	100.0%

4. What Research and Development category would you classify your past and present work units under? Research (6.1); Exploratory Development (6.2); Advanced Development (6.3)

TYPE	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
All 6.2	21	46.7
6.1 and 6.2	5	11.1
6.2 and 6.3	16	35.6
6.1, 6.2, and 6.3	3	6.7
TOTAL	45	100.1%*

The majority of respondents who managed combinations of work units indicated their primary emphasis was on exploratory development (6.2) work units.

*Error due to rounding.

5. What is the average dollar value of your projects?

DOLLARS	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
$100,000 or less	9	20.0
$100,000 to $1,000,000	33	73.3
$1,000,000 or more	3	6.7
TOTAL	45	100.0%

Many project managers, especially those who had managed combinations of 6.2 and 6.3 or 6.1, 6.2, and 6.3 projects were responsible for projects whose dollar values exceeded the limits of the three ranges above. For example, the largest spread reported was $150,000 to $60 million. However, many project managers specified that the majority of their work units were of a particular R&D category. In addition, during the course of the research, it became evident that most exploratory development programs were less than $1 million and most advanced development programs were in excess of $1 million. Therefore, in those instances where the ranges exceeded the three ranges above, the responses were placed in the range in which the majority of the work units were concentrated. Nineteen project managers reported they had managed projects in excess of $1 million, however, only three stated the majority of their projects were $1 million or more.

6. Were projects classified as studies, hardware oriented, or test oriented?

TYPE	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
STUDIES	7	15.6
HARDWARE	4	8.9
TEST	3	6.7
STUDIES & HARDWARE	9	20.0
STUDIES & TEST	3	6.7
HARDWARE & TEST	3	6.7
STUDIES, HARDWARE, & TEST	16	35.6
TOTAL	45	100.2%*

*Error due to rounding.

7. How many contractors normally respond to your Request for Proposals?

NUMBER	RESPONSES	PERCENTAGE OF TOTAL RESPONSES (%)
1 - 10	43	95.6
11 - 20	2	4.4
TOTAL	45	100.0%

The respondents answered this question with either a numerical range or a specific average number. Because the numerical ranges were so diverse, the general ranges of 1-10 and 11-20 were used. Thirty-two respondents provided a single average number which are listed below.

NUMBER	RESPONSES	PERCENTAGE OF TOTAL (45) RESPONSES (%)
3	8	17.8
4	11	24.4
5	6	13.3
6	3	4.4
7	2	4.4
9	1	2.2
10	1	2.2
TOTAL	32	68.7%

8. In general, what type of method(s) do you use to estimate costs?

a. Historical data, such as recent cost proposals and/or recent contracts of similar scope.

Responses - 35

b. Guidance from experienced project managers.

Responses - 6

c. Experience.

Responses - 15

d. Labor and/or cost information provided by potential offerors.

Responses - 3

e. Engineering judgment, educated input, gut feel.

Responses - 5

f. Division or laboratory level cost estimating guidelines.

Responses - 3

g. Estimate completed by local (laboratory or base level) Financial Analysis Office.

Responses - 1

TOTAL RESPONSES - 68

NOTE: There are 23 more responses than project managers interviewed because many respondents used a combination of cost estimating methods. In those instances, each method received one response.

9. How do you estimate labor (manhours/manyears)?

a. Based on labor required for similar programs and tailor manhours either up or down depending on the requirements of new effort.

Responses - 13

b. Receive guidance from experienced project managers.

Responses - 1

c. Determine labor required to do the job based on own experience and/or judgment.

Responses - 7

d. Break effort down into small work packages or subtasks and estimate manhours required for each work package based on experience and/or historical data.

Responses - 6

e. Manpower estimates provided by potential offerors.

Responses - 4

f. Manyears required based on historical data and/or experience.

Responses - 16

g. Gut feel, best guess.

Responses - 2

h. Based on funds available (project manager backs into estimate).

Responses - 3

TOTAL RESPONSES - 52

9. Continued

NOTE: There are seven more responses than project managers interviewed because many respondents used a combination of cost estimating methods. In those instances, each method received one response.

10. Do you subdivide your labor into various education/ experience categories?

a. Yes

Responses - 30 Percentage - 66.7

b. No

Responses - 15 Percentage - 33.3

TOTAL 45 100.0%

Of the 30 "yes" responses 12 project managers indicated the subdivisions were rather broad, such as senior scientist versus technician or professional versus technician.

11. What is your source for the labor rates?

a. Local (laboratory or base level) Business Management Office or Contracting Division.

Responses - 16 Percentage - 35.6

b. Current contracts or recent proposals of potential offerors.

Responses - 20 Percentage - 44.4

c. Combination of a. and b.

Responses - 3 Percentage - 6.7

d. Potential offerors.

Responses - 1 Percentage - 2.2

e. Hearsay from other project managers.

Responses - 1 Percentage - 2.2

f. Not Applicable - Labor rates included in manyear dollar figure.

Responses - 4 Percentage - 6.7

TOTAL RESPONSES - 45

12 & 13* What is your source for overhead rates?

a. Local (laboratory or base level) Business Management Office or Contracting Division.

Responses - 15 Percentage - 33.3

b. Current contracts or recent proposals of potential offerors.

Responses - 20 Percentage - 44.4

c. Combination of a. and b.

Responses - 4 Percentage - 8.9

d. Potential offerors.

Responses - 0 Percentage - 0

e. Combination of b. and d.

Responses - 1 Percentage - 2.2

f. Not Applicable - Overhead is included in manyear dollar figure.

Responses - 5 Percentage - 11.1

TOTAL RESPONSES - 45

*Questions 12 and 13 are essentially identical questions and all respondents gave the same answers for both. Therefore, these two questions were treated as a single question in the analysis of responses.

14. How do you estimate material costs?

a. From current contracts or recent proposals of potential offerors.

Responses - 13 Percentage - 28.9

b. a. plus inflation factor or management reserve*

Responses - 5 Percentage - 11.1

c. a. plus handbooks or vendor catelogs.

Responses - 4 Percentage - 8.9

d. Using experience and/or judgment.

Responses - 5 Percentage - 11.1

e. Directly from potential offerors.

Responses - 1 Percentage - 2.2

f. As a percentage of total project amount or percentage of engineering labor, or part of manufacturing costs.

Responses - 3 Percentage - 6.7

g. Using best guess, gut feel, rule of thumb.

Responses - 6 Percentage - 13.3

h. Not Applicable - Material costs normally not a factor of project manager's contracts, or material costs lumped together with total manyear dollar value.

Responses - 8 Percentage - 17.8

TOTAL RESPONSES - 45

*The five project managers provided the following additional information to response b.

14. Continued

a. Inflation factor of 10-15% used.

b. Inflation factor of 10-12% used.

c. Current inflation factor for particular industry used from U. S. Bureau of Labor Statistics (11:144).

d. 30% management reserve added to material costs.

e. No specific inflation factor provided.

15. How do you estimate tooling or special equipment costs?

a. From current contracts or recent proposals of potential offerors.

Responses - 5 Percentage - 11.1

b. Using experience and/or judgment.

Responses - 4 Percentage - 8.9

c. Directly from potential offerors.

Responses - 2 Percentage - 4.4

d. Using best guess, gut feel, rule of thumb.

Responses - 4 Percentage - 8.9

e. Not Applicable - Tooling and/or special equipment costs normally not a factor of project manager's contracts, or these costs are lumped together with total manyear dollar value.

Responses - 30 Percentage - 66.6

TOTAL RESPONSES - 45

16. How do you estimate travel costs?

a. Estimates of the number of trips required by the contractor, the number of persons required per trip, plus per diem rate, plus airline fares, plus car rental, etc., are made based on past experience and historical data.

Responses - 35 Percentage - 77.8

b. Using a fixed amount*

Responses - 3 Percentage - 6.7

c. Using best guess, gut feel, rule of thumb.

Responses - 1 Percentage - 2.2

d. Ignored because travel costs are usually insignificant, or because travel costs are lumped together with total manyear dollar value.

Responses - 6 Percentage - 13.3

TOTAL RESPONSES - 45

*All three respondents used a fixed travel cost of $1,000 per trip. It is interesting to note that the respondents were from three different laboratories (Armament, Materials, and Rocket Propulsion) which are widely separated geographically.

17. How do you estimate computer costs?

a. From current contracts or recent proposals of potential offerors.

Responses - 13 Percentage - 28.9

b. Based on estimate provided by local (laboratory or base level) computer center.

Responses - 6 Percentage - 13.3

c. Combination of a. and b.

Responses - 7 Percentage - 15.6

d. Using best guess, gut feel, rule of thumb.

Responses - 5 Percentage - 11.1

e. Directly from potential offerors.

Responses - 1 Percentage - 2.2

f. Combination of b. and c.

Responses - 1 Percentage - 2.2

g. Not Applicable - Computer costs are normally not a factor of project manager's contracts or these costs are lumped together with total manyear dollar value.

Responses - 12 Percentage - 26.7

TOTAL RESPONSES - 45

18. What is your source for General and Administrative (G&A) rates?

a. Local Business Management Office or Contracting Division.

Responses - 15 Percentage - 33.3

b. Current contracts or recent proposals of potential offerors.

Responses - 13 Percentage - 28.9

c. Combination of a. and b.

Responses - 3 Percentage - 6.7

d. Not Applicable - G&A rates included in manyear dollar figure or lumped together with overhead rate.

Responses - 14 Percentage - 31.1

TOTAL RESPONSES - 45

19. Do any of the above estimates include inputs from potential offerors?

a. No

Responses - 27 Percentage - 60.0

b. Yes

Responses - 18 Percentage - 40.0

TOTAL 45 100.0%

Six of the "no" respondents said that in some situations potential offerors do provide some cost estimates. The situations mentioned by the respondents were: sole source procurements, unsolicited proposals, draft Requests for Proposals, or instances where the contractor provided cost estimates for future unfunded work which later became a new contractual effort.

20. What is the main cost driver of your work units?

a. Labor, engineering labor, manpower

Responses - 37 Percentage - 82.2

b. Overhead

Responses - 1 Percentage - 2.2

c. Hardware

Responses - 1 Percentage - 2.2

d. a. and b.

Responses - 3 Percentage - 6.7

e. a. and c.

Responses - 1 Percentage - 2.2

f. Test Support

Responses - 1 Percentage - 2.2

g. Technical Uncertainty

Responses - 1 Percentage - 2.2

TOTAL 45 99.9%*

*Error due to rounding.

21. Do you receive JOCAS information periodically?

a. Yes

Responses - 43 Percentage - 95.6

b. No

Responses - 1 Percentage - 2.2

c. Not Sure

Responses - 1 Percentage - 2.2

TOTAL 45 100.0%

22. Do you use the JOCAS information in making your cost estimate for new contractual efforts?

a. Yes

Responses - 3 Percentage - 6.7

b. No

Responses - 40 Percentage - 88.9

c. Somewhat

Responses - 1 Percentage - 2.2

d. Not Applicable - Does not have access to JOCAS

Responses - 1 Percentage - 2.2

TOTAL 45 100.0%

23. Do you use any particular form or format such as DD 633-4, AFWAL 28, AFFTC 296, or AFWL 95 to assist you or to record your estimate?

a. Yes (Local Form)

Responses - 19 Percentage - 42.2

b. Yes (DD 633-4)

Responses - 6 Percentage - 13.3

c. No[1]

Responses - 20 Percentage - 44.4

TOTAL 45 99.9%[2]

1. Eleven of the "No" respondents said they completed some informal, scratch pad type, documentation of the cost estimate.
2. Total percentage does not equal 100% due to rounding error.

24. Do you retain your initial cost estimate in your work unit folder?

a. Yes (Local Form)

Responses - 17 Percentage - 37.8

b. Yes (DD 633-4)

Responses - 8 Percentage - 17.8

c. Yes (Informal Estimate)

Responses - 4 Percentage - 8.9

d. No - No documentation of estimate is retained.

Responses - 16 Percentage - 35.6

TOTAL RESPONSES - 45

25. In general, by what percentage does the offeror's proposed costs differ from your estimated costs?

a. The offeror's costs are generally higher by the following percentage:

PERCENTAGE (%)	RESPONSES
5 - 10	2
10	2
10 - 15	2
10 - 20	5
15	1
15 - 20	1
20	3
20 - 25	1
20 - 40	1
25	4
25 - 30	2
30	1
50 or more	1
5 - 200	1
TOTAL	27

b. An even distribution exists between overbids and underbids by the following percentage:

PERCENTAGE (%)	RESPONSES
5 - 20	1
10	3
20	2
30	2
30 - 50	1
TOTAL	9

c. The offeror's proposed costs differ from the program manager's estimated costs within the range of 30% less to 100% more.

Responses - 1

25. Continued

d. No specific percentage was provided by the program manager interviewed.*

Responses - 8

TOTAL RESPONSES - 45

*Five respondents said they could not provide any particular percentage because they were not sure or did not know what the percentage was. One respondent said the offeror's proposed costs could be as much as 100% above the project manager's costs. One respondent said the offeror's proposed costs are quite often on the high side. Finally, one program manager indicated the difference is surprisingly small.

26. What do you feel are the primary factors that contribute to the differences between your estimate and the offeror's proposed costs?

a. The potential offerors misinterpret the Statement of Work.

Responses - 10

b. The potential offerors propose a different level of effort because of some technical insight that is unknown to the project manager.

Responses - 3

c. Pressure competition. The potential offerors underbid in order to win the contract.

Responses - 3

d. The potential offerors propose a "glamorous" program.

Responses - 1

e. Offeror's lack of experience with government contracts.

Responses - 1

f. The potential offerors add a management reserve or contingency factor which the project manager does not consider in his estimate.

Responses - 2

g. The project manager inaccurately estimates the manhours or labor rates.

Responses - 10

26. Continued

h. The project manager inaccurately estimates the overhead rates.

Responses - 9

i. The project manager inaccurately estimates the inflation rate.

Responses - 6

j. The project manager inaccurately estimates materials, hardware, subcontracting costs, or fee.

Responses - 4

k. The project manager fails to consider fringe benefits in his estimate.

Responses - 1

l. In general, the project manager makes a poor cost estimate or is overly optimistic in his estimate.

Responses - 3

m. The project manager is forced to make a low estimate due to the limited funds available.

Responses - 2

n. The lack of a consistent cost estimating model.

Responses - 1

TOTAL RESPONSES - 56

26. Continued

NOTE: There are 11 more responses than project managers interviewed because some respondents provided more than one factor. If a project manager provided two or more factors then each factor received one response.

27. Is the difference between your estimate and the offeror's proposed costs due in part to the offeror's misinterpretation of the Statement of Work (SOW)?

a. Yes*

Responses - 34 Percentage - 75.56

b. No

Responses - 11 Percentage - 24.44

TOTAL 45 100.00%

*Of the 34 project managers who answered "yes" to this question, 11 said misinterpretation of the SOW occured only "occassionally", "not very often", or "to some extent." In addition, four project managers stated that although misinterpretation of the SOW did occur, they did not consider it a problem.

28. If your estimate does not agree with the offeror's proposed costs, do you attempt to determine, in detail, why and where the differences exist?

a. Yes - in detail

Responses - 32 Percentage - 71.1

b. Yes - but not in detail

Responses - 7 Percentage - 15.6

c. Yes - but only if the cost differential is so great it would prohibit funding of the project.

Responses - 3 Percentage - 6.7

d. No

Responses - 3 Percentage - 6.7

TOTAL RESPONSES - 45

29. At contract completion, do you compare actual costs with your original estimate and/or the contractor's original estimate?

a. Yes

Responses - 16 Percentage - 35.6

b. No

Responses - 26 Percentage - 57.8

c. Sometimes

Responses - 3 Percentage - 6.7

TOTAL 45 100.1%*

*Error due to rounding.

30. Do you feel you have adequate information and/or tools at your disposal to accurately estimate labor and costs?

a. Yes

Responses - 25 Percentage - 55.6

b. No

Responses - 12 Percentage - 26.7

c. To some extent

Responses - 7 Percentage - 15.6

d. Not sure

Responses - 1 Percentage - 2.2

TOTAL 45 100.1%*

*Error due to rounding.

31. Do you feel you have sufficient time to accurately estimate costs?

a. Yes[1]

Responses - 36 Percentage - 80.0

b. No

Responses - 7 Percentage - 15.6

c. Sometimes

Responses - 2 Percentage - 4.4

TOTAL 45 100.0%[2]

1. Four of the respondents indicated that if there is not sufficient time to make an accurate estimate, they will "make" the time at the expense of other duties.
2. Error due to rounding.

32. How do you handle the uncertainties in the estimating process?

a. Add a contingency factor, management reserve, or inflation factor.

Responses - 23 Percentage - 51.1

b. Estimate conservatively or on the high side.

Responses - 9 Percentage - 20.0

c. Make a best guess estimate based on experience.

Responses - 3 Percentage - 6.7

d. Not Applicable - The most realistic estimate possible is made.

Responses - 10 Percentage - 22.2

TOTAL RESPONSES - 45

33. How constrained are you by earlier cost estimates, such as those made during the planning cycle?

a. Very constrained

Responses - 14 Percentage - 31.1

b. Moderately constrained

Responses - 8 Percentage - 17.8

c. Somewhat or not very constrained

Responses - 11 Percentage - 24.4

d. Not constrained at all

Responses - 12 Percentage - 26.7

TOTAL	45	100.0%

34. Summarize your perceptions of the weaknesses in the current cost estimating process.

a. There are no tools, models, guidance, or training to assist the project manager.

Responses - 10

b. The project manager's original planning estimate, which is generally crude and inaccurate, is considered a firm estimate by management and one which the project manager is forced to abide by.

Responses - 9

c. The project manager does not have the technical or cost insight required to accomplish the project goals that industry has.

Responses - 4

d. The project manager must use average rates which often differ significantly from the rates actually proposed by the bidders.

Responses - 3

e. The project manager must rely on the costs of previous projects which are not always accurate or up-to-date.

Responses - 3

f. Some project managers lack the experience in estimating costs.

Responses - 3

34. Continued

g. The high turnover rate results in loss of cost estimating experience.

Responses - 1

h. The project manager is unable to specifically define the level of effort required to accomplish the goals of the project in the Statement of Work.

Responses - 1

i. An accurate cost estimate is difficult to make due to the uniqueness of each project.

Responses - 1

j. A new project is constrained by the funds available not by the estimate of what the project will cost. Consequently, there is little value in attempts to accurately estimate costs.

Responses - 3

k. Policies which prohibit cost and/or manhour discussions with potential offerors, prior to the issuance of the Request for Proposal are too restrictive.

Responses - 3

l. The new formalized cost estimating procedures place an additional paperwork burden on the project manager with no significant increase in the accuracy of the estimates.

34. Continued

Responses - 2

m. Management is under the false impression that cost estimating is quantifiable when, in fact, cost estimating is a result of experience.

Responses - 1

n. Management does not place enough emphasis on the cost estimating process.

Responses - 1

o. There are no weaknesses in the current cost estimating process.

Responses - 6

TOTAL RESPONSES - 51

NOTE: There are six more responses than project managers interviewed because some respondents identified more than one weakness. In those instances, each weakness received one response.

35. What recommendations do you have to improve the current cost estimating system?

a. Provide the project manager access to a computer data bank that contains manhours and costs for past programs and is relatively uncomplicated and simple to use.

Responses - 10

b. Provide the project manager with guidance or formal training in cost estimating methods or procedures.

Responses - 6

c. Provide a staff of cost analysts to assist project managers in making their cost estimates.

Responses - 5

d. Provide the project manager with the flexibility to update his initial planning estimate.

Responses - 6

e. Reduce the restrictions which prohibit discussion between project managers and potential offers. Open discussions concerning cost and manhours would significantly reduce the differences between the project manager's estimate and the proposed costs.

Responses - 5

f. Decrease the procurement lead time. This would reduce the errors resulting from rate increases

35. Continued

that occur from the time an estimate is made and the time the bidder's submit proposals.

Responses - 2

g. The cost estimates made by inexperienced project managers should be reviewed by supervisors or experienced project managers.

Responses - 4

h. Use Draft Request for Proposals.

Responses - 1

i. No recommendations.

Responses - 13

TOTAL RESPONSES - 52

NOTE: There are seven more responses than project managers interviewed because some respondents provided several suggestions for improvement. In those instances, each suggestion received one response.

APPENDIX D

Selected Forms and Formats Used to Record Cost Estimates

In this Appendix several forms and/or formats used throughout the Air Force laboratories are presented. The DD 633-4 shown on pages 160 and 161 was a required item to be submitted by potential offerors when bidding on a proposal. (This form was rescinded in July 1980.) The DD 633-4 is also used by several laboratories to record the project manager's original cost estimate or the estimate accompanying the RFP. The form requires subestimates to be performed for materials, overhead, and direct labor, travel, etc.

The Air Force Flight Test Center (AFFTC) Form 296, used at the Rocket Propulsion Laboratory, is found on page 162. The AFFTC 296 is similar to the DD 633-4 but requires a detailed break out of engineering labor and manufacturing labor by various education and experience categories.

The cost estimating format used at the Armament Laboratory is also similar to the DD 633-4 and AFFTC 296 (see pages 163 and 164). It is accompanied by a set of instructions describing how the form is to be completed. While the instructions are not explicit, they provide the inexperienced project manager with some guidance.

Finally, an estimate of considerable detail, relative to the three previous estimates, can be found on pages 165 through 176. It is a good example of a baseline estimate because it includes: (1) The technical objectives to be achieved (2) A schedule to be maintained, and (3) The resources to be expended. The estimate was developed by Mr. Rudi Berndt of the Flight Dynamics Laboratory. The

estimate begins with an outline of the Statement of Work (SOW) (Pages 165 through 168), followed by a resources/milestone chart (page 169). On pages 170 through 175 an estimate for each phase of the project is shown. These phase estimates are also similar in format to the DD 633-4 and AFFTC 296. The next page, page 176, presents a cost estimate for the laboratory management support, broken out by phases. Page 177 is a summary of the estimate and the rationale for the cost estimate. The last page is not a part of the Flight Dynamics Laboratory cost estimate. It is inserted to illustrate the type of rate information that can be provided to the project managers to assist them in their estimating.

DEPARTMENT OF DEFENSE

CONTRACT PRICING PROPOSAL

(RESEARCH AND DEVELOPMENT)

Form Approved
Budget Bureau No. 22-R100

This form is for use when (1) submission of cost or pricing data (see ASPR 3-807.3) is required and (2) substitution for the DD Form 633 is authorized by the contracting officer.

PAGE NO. | NO. OF PAGES

NAME OF OFFEROR	SUPPLIES AND/OR SERVICES TO BE FURNISHED
HOME OFFICE ADDRESS (Include ZIP Code)	
DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED	TOTAL AMOUNT OF PROPOSAL: $ / GOVT SOLICITATION NO

DETAIL DESCRIPTION OF COST ELEMENTS

	EST COST ($)	TOTAL EST COST ($)	REFERENCE
1. DIRECT MATERIAL (Itemize on Exhibit A)			
a. PURCHASED PARTS			
b. SUBCONTRACTED ITEMS			
c. OTHER (1) RAW MATERIAL			
(2) YOUR STANDARD COMMERCIAL ITEMS			
(3) INTERDIVISIONAL TRANSFERS (At other than cost)			
TOTAL DIRECT MATERIAL			
2. MATERIAL OVERHEAD ( ) Rate % X $ (base)			

3. DIRECT LABOR (Specify)	ESTIMATED HOURS	RATE/HOUR	EST COST ($)	
TOTAL DIRECT LABOR				

4. LABOR OVERHEAD (Specify department or cost center)	O/H RATE	X BASE $	EST COST ($)
TOTAL LABOR OVERHEAD			

	EST COST ($)	
5. SPECIAL TESTING (Including field work at Government installations)		
TOTAL SPECIAL TESTING		
6. SPECIAL EQUIPMENT (If direct charge) (Itemize on Exhibit A)		
7. TRAVEL (If direct charge) (Give details on attached Schedule)	EST COST ($)	
a. TRANSPORTATION		
b. PER DIEM OR SUBSISTENCE		
TOTAL TRAVEL		
8. CONSULTANTS (Identify purpose, etc.)	EST COST ($)	
TOTAL CONSULTANTS		
9. OTHER DIRECT COSTS (Itemize on Exhibit A)		
10. TOTAL DIRECT COST AND OVERHEAD		
11. GENERAL AND ADMINISTRATIVE EXPENSE Rate % of cost element Yes ( )		
12. ROYALTIES*		
13. TOTAL ESTIMATED COST		
14. FEE OR PROFIT		
15. TOTAL ESTIMATED COST AND FEE OR PROFIT		

This proposal is submitted for use in connection with and in response to (Describe RFP, etc.)

and reflects our best estimates as of this date, in accordance with the instructions to offerors and the footnotes which follow.

TYPED NAME AND TITLE	SIGNATURE
NAME OF FIRM	DATE OF SUBMISSION

DD Form 633-4

EXHIBIT A - SUPPORTING SCHEDULE *(Specify. If more space is needed, use blank sheets)*

COST EL NO	ITEM DESCRIPTION *(See instruction 3)*	EST COST *(3)*

I HAVE THE DEPARTMENT OF DEFENSE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, OR THE ATOMIC ENERGY COMMISSION PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

☐ YES ☐ NO *If yes, identify below.*

NAME AND ADDRESS OF REVIEWING OFFICE *(Include ZIP Code)* | TELEPHONE NUMBER/EXTENSION

II WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

☐ YES ☐ NO *If yes, identify on a separate page*

III DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

☐ YES ☐ NO *If yes, identify:* ☐ ADVANCE PAYMENTS ☐ PROGRESS PAYMENTS *OR* ☐ GUARANTEED LOANS

IV DO YOU NOW HOLD ANY CONTRACT *or do you have any independently financed (IR & D) proposals* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT? ☐ YES ☐ NO *If yes, identify*

V DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN ASPR, SECTION XV *(See 3-807.2(c)(3))*?

☐ YES ☐ NO *If no, explain on a separate page.*

INSTRUCTIONS TO OFFERORS

1. The purpose of this form is to provide a standard format by which the offeror submits to the Government a summary of incurred and estimated costs (and *attached supporting information*) suitable for detailed review and analysis. Prior to the award of a contract resulting from this proposal *the offeror* shall, under the conditions stated in ASPR 3-807.3, be required to submit a Certificate of Current Cost or *Pricing Data* (see ASPR 3-807.3(e) and 3-807.4).

2. As part of the specific information required by this form, the *offeror must submit with this form, and clearly identify* as such, cost or pricing data (that is, data which is verifiable and factual and otherwise as *defined* in ASPR 3-807.3(e)). In addition, he must submit with this form any information reasonably required to explain the offeror's estimating process, including:

   a. the judgmental factors applied and the mathematical or other methods used in the estimate including those used in projecting from known data, and

   b. the contingencies used by offeror in his proposed price.

3. Where attachment of supporting cost or pricing data to this form is impracticable, the data will be specifically identified and described (*with schedules as appropriate*), and made available to the contracting officer or his representative upon request.

4. The format for the "Cost Elements" is not intended as rigid requirements. These may be presented in *different* format with the prior approval of the contracting officer if required for more effective and efficient presentation. In all other respects this form will be completed and submitted without change.

5. By submission of this proposal offeror, if selected for negotiation, grants to the contracting officer or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along *with the computations and projections used therein.* This right may be exercised in connection with any negotiations prior to contract award.

FOOTNOTES

1 Enter in the column those necessary and reasonable costs which in the judgment of the offeror will properly be incurred in the efficient performance of the contract. When any of the costs in this column have already been incurred (e.g., on a letter contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your plants, divisions, or organizations under a common control, which are included at other than the lower of cost to the original transferor or current market price.

2 When data in addition to that available in Exhibit A is required, attach separate pages as necessary and identify in this "Reference" column the alignment in which information supporting the specific cost element may be found. No standard format is prescribed, however the cost or pricing data must be accurate, complete and current, and the judgment factors used in projecting from the data to the estimates must be stated in sufficient detail to enable the contracting officer to evaluate the proposal. For example, provide the basis used for pricing materials such as by vendor quotations, shop estimates, or invoice prices; the reason for use of overhead rates which are significantly different from experienced rates (reduced volume, planned major rearrangement, etc.); or justification for increase in labor rates (anticipated wage and salary increases). Identify and explain any contingencies which are included in the proposed price, such as anticipated costs of rejects and defective work, or anticipated technical difficulties.

3 Indicate the rates used and provide an appropriate explanation. Where agreement has been reached with Government representatives on the use of forward pricing rates, describe the nature of the agreement. Provide the method of computation and application of your overhead expense, including cost breakdowns and showing trends and budgetary data to support such rates.

4 If the total royalty cost entered here is in excess of $250 provide on a separate page (or on DD Form 783, Royalty Report) the following information on each separate item of royalty or license fee: name and address of licensor, date of license agreement, patent numbers, patent application serial numbers, or other basis on which the royalty is payable, brief description, including any part or model numbers of each component on which the royalty is payable, percentage or dollar rate of royalty per unit, unit price of contract item, and total dollar amount of royalties.

5 If specifically requested by the contracting officer, a copy of the current license agreement, and identification of applicable claims of specific patents shall be provided.

6 Provide a list of principal items within each category indicating known or anticipated sources, quantity, unit price, competition obtained, and basis of establishing source and reasonableness of cost.

PROGRAM ESTIMATING DETAIL SHEET	ESTIMATOR, OFFICE SYMBOL AND PHONE NO. JOHN J. JONES AFRPL/MKM 32537	ESTIMATE DATE 11 Oct 77
PURCHASE REQUEST NUMBER	ESTIMATED PROGRAM MIDPOINT OF EFFORT July 1978	ESTIMATE FOR TOTAL PROGRAM OR FOR PHASE/TASK Total Program

DETAIL DESCRIPTION OF COST ELEMENTS

1. DIRECT MATERIAL			EST COST ($)	TOTAL EST COST
A. PURCHASED PARTS			10,000	
B. SUBCONTRACTED ITEMS			13,000	
C. RAW MATERIAL			5,000	
		TOTAL DIRECT MATERIAL		28,000
2. DIRECT LABOR CATEGORIES (As Applicable)	ESTIMATED HOURS	RATE/ HOUR	EST COST ($)	
A. ENGINEERING LABOR CATEGORIES				
(1) PHD+4, OR MS+6, OR BS+10 OR 14 YRS EQUIVALENT EXPERIENCE		12.91		
(2) PHD+2, OR MS+4, OR BS+8 OR 12 YRS EQUIVALENT EXPERIENCE	2,080	12.71	26,437	
(3) PHD, OR MS+2, OR BS+6 OR 10 YRS EQUIVALENT EXPERIENCE		12.10		
(4) MS, OR BS+4 OR 8 YRS EQUIVALENT WORK EXPERIENCE		12.05		
(5) BS+2 YRS OR EQUIVALENT WORK EXPERIENCE	4,000	11.90	47,600	
(6) ENTRY LEVEL, BS OR EQUIV WORK EXPERIENCE		10.89		
(7) ELECTRONIC, TEST, MECHANICAL TECHNICIAN, ETC.		11.10		
(8) TECHNICAL WRITER, DRAFTSMAN, COMPUTER OPERATOR, ETC.		9.78		
B. MANUFACTURING LABOR CATEGORIES				
(1) MANUFACTURING ENGINEER		9.20		
(2) FOREMAN	1,600	8.66	13,856	
(3) JOURNEYMAN	4,800	8.27	39,696	
(4) APPRENTICE		8.11		
(5) SEMI-SKILLED	800	7.24	5,790	
(6) UNSKILLED		5.93		
	TOTAL DIRECT LABOR			133,381
3. LABOR OVERHEAD	O.H. RATE	X BASE =	EST COST ($)	
A. ENGINEERING	140	74,037	103,651	
B. MANUFACTURING	225	59,344	133,524	
	TOTAL LABOR OVERHEAD			237,175
4. COMPUTER				3,500
5. SPECIAL EQUIPMENT/TOOLING				2,013
6. TRAVEL				780
7. CONSULTANTS				0
8. OTHER DIRECT COSTS			EST COST ($)	
CAS 414 Cost of Money			10,691	
		TOTAL OTHER DIRECT COSTS		10,691
9.		TOTAL DIRECT COST AND OVERHEAD		415,540
10. GENERAL AND ADMINISTRATIVE EXPENSE (Rate 40 %)				166,216
11.		TOTAL ESTIMATED COST		581,756
12. FEE OR PROFIT 8%				45,343
13.		TOTAL ESTIMATED COST AND FEE OR PROFIT		627,099

AFFTC FORM MAR 77 296

ENGINEERING ESTIMATE

TOTAL MATERIAL			_____
Direct Material		_____	
Raw Material	_____		
Purchased Parts	_____		
Subcontracted Items	_____		
Other	_____		
Material Overhead		_____	
TOTAL LABOR			_____
Direct Labor		_____	
Labor Overhead		_____	
Testing			_____
Special Equipment			_____
Travel			_____
Transportation		_____	
Per Diem or Subsistence		_____	
Consultants			_____
General and Administrative			_____
Fee or Profit			_____
TOTAL			_____

INSTRUCTIONS

1. List the materials required to do the job, and their cost. List all items to be subcontracted and the expected cost.

2. Estimate material overhead. Multiply overhead rate times total direct material.

3. List the major tasks to be performed, and the hours associated with each, along with the rate expected per hour. Multiply estimated hours times the expected rate per hour to arrive at the estimated cost.

4. Estimate labor overhead. Multiply overhead times total direct labor.

5. List any testing requirements expected, along with the anticipated cost.

6. Identify the type and cost of any Special Equipment necessary to complete the program.

7. Estimate the number of trips to be accomplished during the life of the contract and the cost of each trip.

8. List any consultants required, along with their fee. Describe the purpose for each consultant.

9. General and Administraive Expense may be estimated by the percentage of the cost of all the above noted areas. To arrive at this percentage, call Lt Stone (882-4628) or Procurement (2-4141) to discuss the rates associated with the specified types of contractors expected to respond.

10. Estimate the Fee or Profit to be associated with this contract. This normally depends on the type of contract to be let. Use the following chart to estimate:

FFP	Building of an item	12-13%
FFP	Research Only	5-8%
CPFF	Mostly Research	5-8%
CPFF	Need for State of Art Knowledge	9-10%

SOW OUTLINE 2 Oct 80

ADVANCED HIGH TEMPERATURE RESISTANT TRANSPARENCIES FOR HIGH SPEED AIRCRAFT

1.0 INTRODUCTION (OBJECTIVE)

- a. Overview of technical area
- b. Need for this program.
  - (1) Requirement
  - (2) Present state-of-the-art
  - (3) Data voids
- c. What must be done
- d. Specific program objective
- e. Specific program payoff to Air Force

2.0 SCOPE (OVERALL PICTURE OF DESIRED WORK)

- a. Outline of phases or tasks
- b. Specific technical objectives
- c. Limitations
- d. Desired products

3.0 GENERAL BACKGROUND

- a. Background necessary to understand requirements
- b. How did procurement arise
- c. Relationship to other programs
- d. Importance of this new work
- e. Techniques previously tried
  - (1) Successful ones
  - (2) Unsuccessful ones
- f. Listing of applicable technical reports

4.0 TECHNICAL REQUIREMENTS/TASKS

4.1 Task I - General Thermal Analyzer Program (GTAP)

- a. Select state-of-the-art GTAP

b. Operate GTAP using existing data

c. Deliver GTAP to WPAFB

d. Define requirements for Specific Thermal Analyzer Program for Aircraft Transparencies (STAPAT)

(1) Sensitivity analyses using GTAP

(a) Heat transfer coefficient

(b) Recovery temperature

(c) Material thermophysical properties

(d) Latteral and longitudinal distributions

(2) Capabilities desired

(a) Input variables and format

(b) Range of applicability

1. Mach number

2. Geometry

3. Heating types

a. Aerodynamic

b. Runway

c. De-ice/de-fog

d. Active cooling

4. Dimensionality

(c) Tie-in to MAGNA

(d) Subroutine manipulation

(e) Output variables and format

(3) Voids and weaknesses

(a) Program operation

(b) Aerothermodynamic subroutines

4.2 Task II - STAPAT Operation

a. Develop input subprograms

b. Develop subroutine manipulation program

c. Develop output subprograms

d. Demonstrate operation with existing subroutines

e. Deliver STAPAT to WPAFB

f. Develop programs for new subroutines

4.3 Task III - STAPAT Aerothermodynamic Subroutines

a. Develop needed subroutines from existing analytical and empirical calculation techniques

(1) Inviscid aerodynamics

(2) Viscous aerothermodynamics

(3) Heat transfer mechanisms

(4) Material thermophysical properties

b. Develop needed subroutines from Wind Tunnel Test Program

(1) Program definition/requirements

(a) Fuselage

(b) Windshield/canopy protuberance

(c) Corner/3-D effects

(d) Windshield/canopy interface

(e) Test plan

(2) Model design and fabrication

(3) Wind tunnel tests

(4) Data analysis

(5) Subroutine development

c. Develop needed subroutines from Materials Properties Test Program

4.4 Task IV - STAPAT Demonstration

a. Incorporate new subroutines

b. Demonstrate STAPAT

(1) Operation

(2) Thermal performance prediction

c. Define new state-of-the-art

e. Deliver STAPAT to WPAFB

4.5 Other Areas of Consideration

a. Reliability and Maintainability

b. Systems Safety

c. Design to Cost and Value Engineering

5.0 REPORTS, DATA, AND OTHER DELIVERABLES

6.0 INITIATION OF CONTRACT MEETING

X INITIAL
CHANGE NO. ____

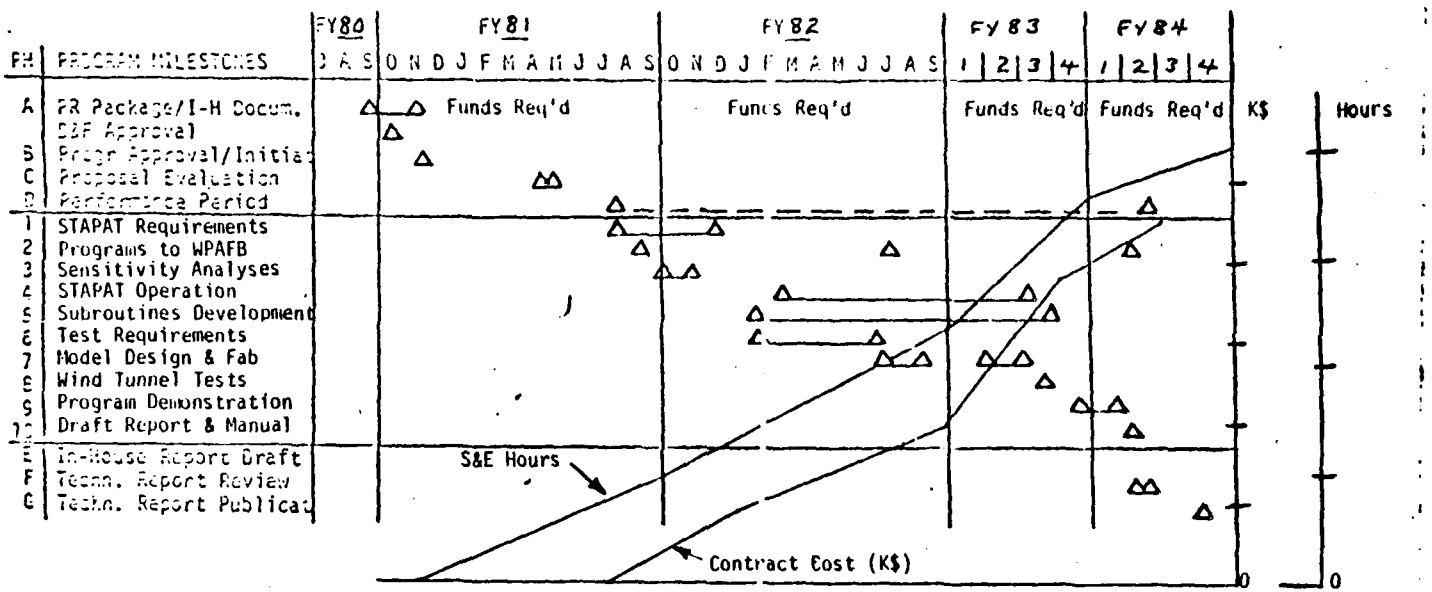
PROGRAM BASELINE
WORK UNIT/SUPPORT EFFORT CATEGORY 1

DATE 7 Oct 80

A. PROGRAM TITLE: Advanced High Temperature Resistant Transparencies for High Speed Aircraft. JOAP/JON ____/____

B. TECHNICAL OBJECTIVE: To develop those design criteria and analysis methods required to extend the thermal performance capabilities of lightweight, bird impact resistant, and large field-of-view windshields and canopies of supersonic aircraft.

C. SCHEDULE:



Q. INITIAL COST ESTIMATE

PAGE 1 (1) EXTRAMURAL PROGRAM DATE 7 Oct 80

I. CONTRACT COST

PHASE 1, General Thermal Analyzer Program PERIOD 6 MONTHS

1. Labor Engineering (Direct Labor) (See Note 1)

Professional	700 Hrs @ $ 20 /Hr =	$14,000		
Technician	160 Hrs @ $ 15 /Hr =	$ 2,400		
Administrative	60 Hrs @ $ 15 /Hr =	$ 900		
	TOTAL DIRECT LABOR	$17,300	$ 17,300	

2. Labor Overhead - Engineering

Overhead Rate 120 % of Total Direct Labor Cost $ 20,760

3. Materials (See Note 2)

Purchased Parts	$	
Raw Materials	$	
Subcontracted Items	$	
TOTAL MATERIALS	$ 0	$ 0

4. Materials Overhead

Overhead Rate ____ % of Total Materials Cost $ 0

5. Consultants (See Note 3)

____ Days x $ ____/Day = $ 0

6. Other Direct Costs (See Note 4)

Computer Usage	$ 10,000	
Printing	$ 0	
Other	$ 0	
TOTAL OTHER DIRECT COSTS	$ 10,000	$ 10,000

7. Travel (See Note 5) $ 1,940

SUB-TOTAL $ 50,000

8. General and Administrative (G&A)

G&A Rate 20 % of Sub-Total $ 10,000

TOTAL ESTIMATED COST $ 60,000

Q. INITIAL COST ESTIMATE

PAGE 2 (1) EXTRAMURAL PROGRAM DATE 7 Oct 80

I. CONTRACT COST

PHASE 2, STAPAT Operation PERIOD 17 MONTHS

1. Labor Engineering (Direct Labor) (See Note 1)

Professional	500 Hrs @ $ 25 /Hr =	$ 12,500		
Technician	80 Hrs @ $ 20 /Hr =	$ 1,600		
Administrative	45 Hrs @ $ 20 /Hr =	$ 900		
	TOTAL DIRECT LABOR	$ 15,000	$ 15,000	

2. Labor Overhead - Engineering

Overhead Rate 125 % of Total Direct Labor Cost $ 18,750

3. Materials (See Note 2)

Purchased Parts	$	
Raw Materials	$	
Subcontracted Items	$	
TOTAL MATERIALS	$ 0	$ 0

4. Materials Overhead

Overhead Rate ____ % of Total Materials Cost $ 0

5. Consultants (See Note 3)

____ Days x $ ____ /Day = $ 0

6. Other Direct Costs (See Note 4)

Computer Usage	$ 11,000	
Printing	$ 0	
Other	$ 0	
TOTAL OTHER DIRECT COSTS	$ 11,000	$ 11,000

7. Travel (See Note 5) $ 1,650

SUB-TOTAL $ 46,400

8. General and Administrative (G&A)

G&A Rate 25 % of Sub-Total $ 11,600

TOTAL ESTIMATED COST $ 58,000

Q. INITIAL COST ESTIMATE

PAGE 3 (1) EXTRAMURAL PROGRAM DATE 3 Oct 80

I. CONTRACT COST

PHASE 3, STAPAT Aerothermo Dynamics PERIOD 20 MONTHS

1. Labor Engineering (Direct Labor) (See Note 1)

Professional	1000 Hrs @ $	25 /Hr =	$ 25,000	
Technician	500 Hrs @ $	20 /Hr =	$ 10,000	
Administrative	100 Hrs @ $	20 /Hr =	$ 2,000	
	TOTAL DIRECT LABOR		$ 37,000	$ 37,000

2. Labor Overhead - Engineering

Overhead Rate 125 % of Total Direct Labor Cost $ 46,250

3. Materials (See Note 2)

Purchased Parts	$ 0	
Raw Materials	$ 5,000	
Subcontracted Items	$50,000	
TOTAL MATERIALS	$55.000	$ 55,000

4. Materials Overhead

Overhead Rate 35 % of Total Materials Cost $ 19,250

5. Consultants (See Note 3)

_____ Days x $ _____/Day = $ 0

6. Other Direct Costs (See Note 4)

Computer Usage	$ 0	
Printing	$ 0	
Other	$ 0	
TOTAL OTHER DIRECT COSTS	$ 0	$ 0

7. Travel (See Note 5) $ 2,500

SUB-TOTAL $160,000

8. General and Administrative (G&A)

G&A Rate 25 % of Sub-Total $ 40,000

TOTAL ESTIMATED COST $200,000

D. INITIAL COST ESTIMATE

PAGE 4 (1) EXTRAMURAL PROGRAM DATE 7 Oct 80

I. CONTRACT COST

PHASE 4, STAPAT Demonstration PERIOD 5 MONTHS

1. Labor Engineering (Direct Labor) (See Note 1)

Professional	250 Hrs @ $ 30 /Hr =		$ 7,500	
Technician	40 Hrs @ $ 25 /Hr =		$ 1,000	
Administrative	20 Hrs @ $ 25 /Hr =		$ 500	
	TOTAL DIRECT LABOR	$9,000		$ 9,000

2. Labor Overhead - Engineering

Overhead Rate 130 % of Total Direct Labor Cost $ 11,700

3. Materials (See Note 2)

Purchased Parts	$		
Raw Materials	$		
Subcontracted Items	$		
TOTAL MATERIALS	$ 0		$ 0

4. Materials Overhead

Overhead Rate ____ % of Total Materials Cost $ 0

5. Consultants (See Note 3)

____ Days x $ ____/Day = $ 0

6. Other Direct Costs (See Note 4)

Computer Usage	$ 8,000		
Printing	$ 0		
Other	$ 0		
TOTAL OTHER DIRECT COSTS	$ 8,000		$ 8,000

7. Travel (See Note 5) $ 2,069

SUB-TOTAL $30,769

8. General and Administrative (G&A)

G&A Rate 30 % of Sub-Total $ 9,231

TOTAL ESTIMATED COST $40,000

Q. INITIAL COST ESTIMATE

PAGE 5 (1) EXTRAVEHICULAR PROGRAM DATE 7 Oct 80

I. CONTRACT COST

PHASE 5, Data Requirements PERIOD 32 MONTHS

1. Labor Engineering (Direct Labor) (See Note 1)

Professional	160 Hrs @ $	25 /Hr = $	4,000	
Technician	0 Hrs @ $	20 /Hr = $	0	
Administrative	700 Hrs @ $	20 /Hr = $	14,000	
	TOTAL DIRECT LABOR		$18,000	$ 18,000

2. Labor Overhead - Engineering

Overhead Rate 125 % of Total Direct Labor Cost $ 22,500

3. Materials (See Note 2)

Purchased Parts	$	
Raw Materials	$	
Subcontracted Items	$	
TOTAL MATERIALS	$ 0	$ 0

4. Materials Overhead

Overhead Rate ____ % of Total Materials Cost $ 0

5. Consultants (See Note 3)

____ Days x $ ____ /Day = $ 0

6. Other Direct Costs (See Note 4)

Computer Usage	$ 0	
Printing	$ 2,000	
Other	$ 2,009	
TOTAL OTHER DIRECT COSTS	$4,009	$ 4,009

7. Travel (See Note 5) $ 0

SUB-TOTAL $44,509

8. General and Administrative (G&A)

G&A Rate 25 % of Sub-Total $11,127

TOTAL ESTIMATED COST $55,636

D. INITIAL COST ESTIMATE

PAGE 6 (1) EXTRAMURAL PROGRAM DATE 7 Oct 80

I. CONTRACT COST (Cont'd)

9. Total Program Cost

Phase 1 Total Estimated Cost (G TAP)	$ 60,000	
Phase 2 Total Estimated Cost (Operation)	$ 58,000	
Phase 3 Total Estimated Cost (AERO)	$ 200,000	
Phase 4 Total Estimated Cost (DEMO)	$ 40,000	
Phase 5 Total Estimated Cost (DATA)	$ 55,636	
Phase 6 Total Estimated Cost	$	
Phase 7 Total Estimated Cost	$	
Phase 8 Total Estimated Cost	$	
Phase 9 Total Estimated Cost	$	
Phase 10 Total Estimated Cost	$	
TOTAL ESTIMATED COST	$ 413,636	$ 413,636

10. Profit or Fee

10 % of Total Estimated Cost $ 41,364

TOTAL ESTIMATED CONTRACT COST $ 455,000

II. COST ESTIMATE FOR TEST AND EVALUATION (T&E) SUPPORT

1. Reimbursement to AFSC Test Center (See Note 6)

Funds Required in FY 82	$ 50,000
Funds Required in FY 83	$ 100,000
Funds Required in FY ____	$

2. Reimbursement to Other Test Facilities (See Note 7)

Funds Required in FY ____	$
Funds Required in FY ____	$
Funds Required in FY ____	$

D. INITIAL COST ESTIMATE

PAGE 7 (1) EXTRAMURAL PROGRAM DATE 7 Oct 80

III. COST ESTIMATE FOR LABORATORY MANAGEMENT SUPPORT

1. Phase A, PURCHASE REQUEST PREPARATION — FY 81
   a. S&E 80 hrs @ $ 25 /Hr = $ 2,000
   b. Travel (See Note A) $ 0

2. Phase B, PROGRAM APPROVAL/INITIATION — FY 81
   a. S&E 20 Hrs @ $ 25 /Hr = $ 500

3. Phase C, PROPOSAL EVALUATION — FY 81
   a. S&E 80 Hrs @ $ 25 /Hr = $ 2,000

4. Phase D, PERFORMANCE PERIOD — FY 81
   a. S&E 200 Hrs @ $ 25 /Hr = $ 5,000
   b. Travel (See Note B) $ 1,000
   c. Other (See Note C) $ 0

   FY 82
   a. S&E 700 Hrs @ $ 27 /Hr = $ 18,900
   b. Travel (See Note B) $ 2,000
   c. Other Mission Support (See Note C) $ 0

   FY 83
   a. S&E 700 Hrs @ $ 30 /Hr = $ 21,000
   b. Travel (See Note B) $ 2,000
   c. Other Mission Support (See Note C) $ 0

   FY 84
   a. S&E 200 Hrs @ $ 33 /Hr = $ 6,600
   b. Travel (See Note B) $ 1,000
   c. Other Mission Support (See Note C) $ 0

5. Phase F, TECHNICAL REPORT REVIEW — FY 84
   a. S&E 80 Hrs @ $ 33 /Hr = $ 2,640
   b. Travel (See Note B)

6. Phase G, TECHNICAL REPORT PUBLICATION — FY 84
   a. S&E 40 Hrs @ $ 33 /Hr = $ 1,320

D. INITIAL COST ESTIMATE

(1) EXTRAMURAL PROGRAM

PAGE 8

DATE 7 Oct 80

IV. TOTAL PROGRAM COST/REQUIREMENTS BY FISCAL YEAR ($K)

	FY 81	FY 82	FY 83	FY 84	FY___	TOTAL
1. CONTRACT	55,000	150,000	200,000	50,000	_____	455,000
2. T&E SUPPORT	0	50,000	100,000	0	_____	150,000
TOTAL	55,000	200,000	300,000	50,000	_____	605,000
3. MISSION SUPT (Less Payroll)	1,000	2,000	2,000	1,000	_____	6,000

V. RATIONALE FOR COST ESTIMATE DEVELOPMENT

Cost estimates for phases were based upon information from a recent cost proposal on a similar R&D effort by a major airframe company. Projected inflation rates were included.

Laboratory management support cost estimates were based upon recent expenditures for a similar contract effort.

Costs by fiscal years were based upon the estimated contract cost as a function of time, with allowances for estimating errors and delays in obligation of funds, so that stop-work situations can be avoided.

Review Date Jan 82

Div. Init. [illegible]

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AUTHOR BIOGRAPHICAL SKETCH

Captain Scheel enlisted in the Air Force in 1968 and spent six years as a Flight Simulator Technician. In 1974 he was selected for the Airman's Education and Commissioning Program and received his B. S. in Chemical Engineering from New Mexico State University in 1976. In September 1976, upon completion of Officers Training School, he was assigned to the Air Force Rocket Propulsion Laboratory (AFRPL), Edwards AFB CA. During Captain Scheel's three and one-half years at AFRPL he was a project manager for numerous contractual projects involving the development of solid rocket boosters for space, strategic, and air launched systems. Captain Scheel is married to the former Ceferina Delgado and has two children, Chris and Brian.


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